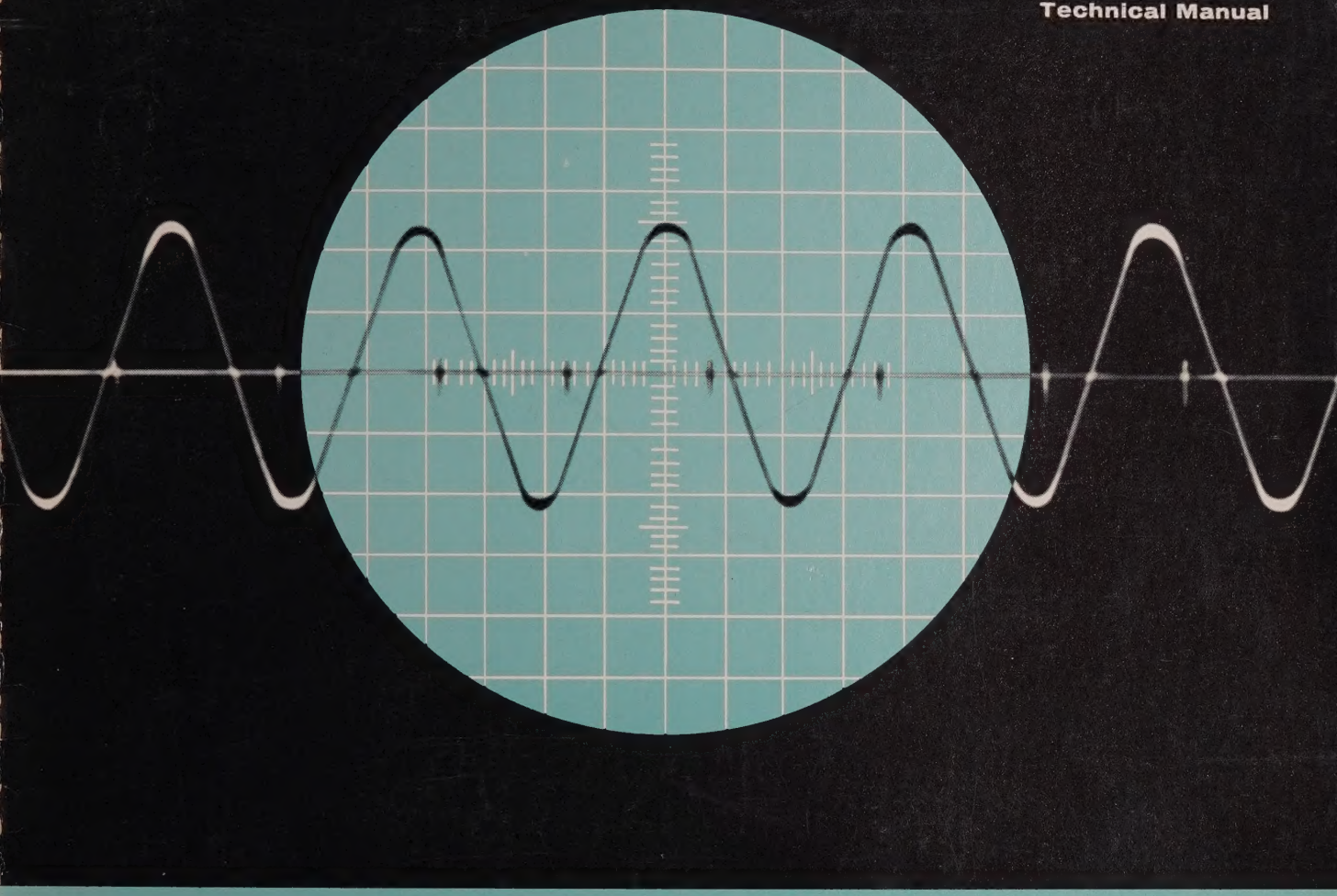
Technical Manual



VIDEO SWEEP GENERATOR

MODEL 1015

JERROLD

ELECTRONICS CORPORATION
INDUSTRIAL PRODUCTS DIVISION

ANALYTICAL LABORATORY INSTRUMENTS FOR QUANTITATIVE MEASUREMENTS

JERROLD®

INSTRUCTION MANUAL
435-382.1

VIDEO SWEEP GENERATOR

MODEL 1015

JERROLD ELECTRONICS CORPORATION - INDUSTRIAL PRODUCTS DIVISION
PHILADELPHIA, PA., 19132

LKE MAY, 1965

NOTES : This manual is shipped with Model 1015, Serial No. _____

All data in this manual are subject to change without notice.

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VIDEO SWEEP GENERATOR MODEL 1015

INTRODUCTION

Jerrold Model 1015 is an instrument for accurate measurement of video frequency circuits and passive networks (such as LC filters) over frequencies ranging from 1 kc to 15 mc.

Model 1015 can be operated at three output modes:

1. wide-band sweep output with sweep widths continuously variable from approximately O to 15 mc for any frequency within 1 kc and 15 mc;
2. narrow-band sweep output with sweep widths continuously variable from approximately O to 200 kc for any frequency within 1 kc and 15 mc;
3. continuous-wave output of any single frequency between 1 kc and 15 mc.

Two sweep modes are available through a selector switch: automatic (with sweep driven by a pyramid generator), and manual.
Sweep repetition rates are continuously variable from one sweep per 2.5 minutes to 60 sweeps per second, in four switchable, overlapping ranges.

A built-in marker generator and amplifier provides a frequency marker selectable by the logging control when the instrument is operated in the wide mode. In addition, special input circuitry permits connection of two external marker generators. A built-in coaxial switch permits comparison of the loss of a network under test against the loss of a standard attenuator - especially useful for fast, accurate, repetitive production line tests.

The instrument features a calibrated output meter, a calibrated frequency scale, and a well-regulated power supply.

SPECIFICATIONS

OUTPUT MODES	WIDE (wide-band sweep) NARROW (narrow-band sweep) CW (continuous wave)
FREQUENCY RANGE	Continuously variable from 1 kc to 15 mc for any output mode
SWEEP WIDTH	WIDE MODE: Sweeps between any two frequencies in the range of 1 kc to 15 mc NARROW MODE: Continuously variable from approximately 0 to 200 kc about selected center frequency within the range of 1 kc to 15 mc.
FLATNESS	0.15 db p-p over the range of 10 kc to 15 mc
SWEEP LINEARITY	WIDE MODE: Quasi-logarithmic NARROW MODE: Linear
RESIDUAL F-M	WIDE MODE: 700 cps p-p maximum NARROW MODE: 10 cps p-p maximum CW MODE: 10 cps p-p maximum
OUTPUT IMPEDANCE	50 or 75 ohms; VSWR 1.07:1 maximum (29.5 db minimum return loss)
OUTPUT POWER LEVEL	Variable, with maximum of 20 dbm into rated load
HARMONICS	At least 40 db below fundamental at max. output, more at lower output levels
POWER REQUIREMENTS	250 watts approx.; 115/230 vac, 60/50 cps.

CHART OF CONTROLS AND CONNECTIONS

NAME OF CONTROL	CIRCUIT DESIG-NATION	TYPE	POSITION	FUNCTION
FRONT PANEL				
SWEEP FUNCTION	S4	3-pos. switch	NARROW WIDE CW	Provides narrow-sweep output mode Provides wide-sweep output mode Provides continuous-wave output mode
SWEEP WIDTH	R4	Pot.	full ccw to full cw	Controls sweep width in either NARROW or WIDE position of SWEEP FUNCTION switch. Vernier dial reads from 0 to 1000 for accurate logging reference in either NARROW or WIDE position of SWEEP FUNCTION switch
WIDE SWEEP CENTER FREQ	R3	Pot.	full ccw to full cw	Functions only in WIDE position of SWEEP FUNCTION switch to determine starting frequency of range to be swept. Vernier dial reads from 0 to 1000 for accurate logging reference in WIDE position of SWEEP FUNCTION switch
SWEEP RATE SW/MIN-SW/SEC	S1	4-pos. switch	.4-4 4-40 .6-6 6-60	Provides sweep rates from 0.4 to 4 sweeps per minute Provides sweep rates from 4 to 40 sweeps per minute Provides sweep rates from 0.6 to 6 sweeps per second Provides sweep rates from 6 to 60 sweeps per second
FINE	R1	Pot.	full ccw to full cw full ccw full cw	Varies sweep repetition rate within limits determined by position of SW/MIN-SW/SEC switch. Minimum rate Maximum rate

NAME OF CONTROL	CIRCUIT DESIG - NATION	TYPE	POSITION	FUNCTION
COAX SWITCHER	S2	3-pos. switch		Selects the function of the coaxial switcher.
			REF	Permits steady observation of refere nce wave-form.
			TEST	Permits steady observation of test waveform.
			AUTO	Permits alternate observation of reference and test wave-form in synchronization with the sweep repetition rate. NOTE: At higher sweep repetition rates, the two phenomena will appear to occur simultaneously.
OUTPUT LEVEL	R8	Pot.	full ccw to full cw	Varies amplitude of output signal.
ALC ON	S6	Push-pull		Switches automatic level control circuit in or out.
			in	Normal position with ALC circuit maintaining the signal output level nearly constant.
			out	ALC circuit de-energized.
PYR SWEEP-MANUAL	S5	Toggle Switch		Selects method of sweeping.
			PYR	Sweep driven automatically by pyramid generator.
			MANUAL	Sweep controlled by rotation of MANUAL SWEEP control.
MANUAL SWEEP	R6	Pot.	full ccw to full cw	Permits observation of a particular section or sections of the sweep.

NAME OF CONTROL	CIRCUIT DESIG - NATION	TYPE	POSITION	FUNCTION
MARKER GAIN	R2	Pot.	full ccw to full cw	Varies the amplitude of any external markers fed to the instrument as well as the amplitude of the internal marker generated with the SWEEP FUNCTION switch in WIDE position
POWER	S3	Toggle switch	ON(up) (down)	Energizes instrument De-energizes instrument
METER	M1			Indicates signal output level available at VIDEO OUTPUT fitting. Calibrated at 14 and 20 dbm
SCALES DIS - PLAY PANEL			upper scale inset dial lower scale	Calibrated from 0 to 15 mc in 200 kc increments Provides 100 indices between any two marks on lower scale. Zero is cali - brated at the 10 index and 15 mc is calibrated at the 490 mark of the scale. Reads from 0 to 500 ; to be used in con- junction with inset dial to provide vern- ier logging for accurate re-settability.
LOGGING CON- TROL (unmarked large knob below scales display panel)	C351 AB	dual cap.	full ccw to full cw full ccw full cw	Controls movement of indicator across scales ; used for setting center frequ - ency of sweep when SWEEP FUNCTION switch is in NARROW or CW position. Used for setting frequency at which int - ernally generated marker appears when SWEEP FUNCTION switch is in WIDE position. Indicator will be to the left of the 0 point on MEGACYCLES (upper) scale. Indicator will be to the right of the 15 point on MEGACYCLES (upper) scale.

NAME OF CONTROL	CIRCUIT DESIG - NATION	TYPE	POSITION	FUNCTION
PYRAMID GENERATOR and SWEEP DRIVER CHASSIS				
PYR REF	R207	Pot.	full ccw to full cw	Sets pyramid negative excursion to zero volts.
PYR AMPL	R202	Pot.	full ccw to	Sets amplitude of pyramid positive excursion to + 40 volts.
PTR SYM	R217	Pot.	full ccw to full cw	Adjusts pyramid wave-form to be symmetrical for both rise and fall (trace and retrace).
80 V ADJ	R233	Pot.	full ccw to full cw	Adjusts for narrowest sweep of wide sweep driver.
C F RANGE	R236	Pot.	full ccw to	Limits range of WIDE SWEEP CENT FREQ control.
W S RANGE	R231	Pot.	full ccw to full cw	Limits range of SWEEP WIDTH control.
N S BAL	R226	Pot.	full ccw to full cw	Balances pyramid excursions above and below zero level when SWEEP FUNCTION switch is in NARROW position.
MIXER and VIDEO AMPLIFIER CHASSIS				
METER CAL	R457	Pot.	full ccw to full cw	Calibrates output meter to + 20 db.
MIXER BIAS	R416	Pot.	full ccw to full cw	Factory-set bias of mixer stage for suppression of harmonics.
MIXER DRIVE	R404	Pot.	full ccw to full cw	Factory-set to control signal amplitude to the mixer for suppression of harmonics.
MIXER BAL	R412	Pot.	full ccw to full cw	Factory-set to balance mixer stage for suppression of harmonics.

NAME OF CONTROL	CIRCUIT DESIG - NATION	TYPE	POSITION	FUNCTION
OSCILLATOR COIL ASSEMBLY CHASSIS				
55 MC MARKER	C354	Cap.		Sets marker oscillator natural frequency at 55 mc (0 on MEGACYCLE scale)
40 MC MARKER	L323	Induct.		Calibrates the marker oscillator natural frequency at 40 mc (15 on MEGACYCLE scale)
WS 55 MC	C346	Cap.		Sets wide sweep oscillator natural frequency at 55 mc
NS 55 MC	C340	Cap.		Sets narrow sweep oscillator natural frequency at 55 mc
MAIN CHASSIS - REAR APRON				
200 V ADJ	R121	Pot.	full ccw to full cw	Adjusts output voltage of regulator to +200 volts
RIPPLE BAL	R108	Pot.	full ccw to full cw	Adjusts +200 volt supply for minimum ripple content
MAN SW RANGE	R131	Pot.	full ccw to full cw	Adjusts MANUAL SWEEP control voltage to 40 volts (with an oscilloscope connected)

NOTE : ALL FITTINGS ON THE REAR APRON ARE CLEARLY MARKED FOR THEIR INDIVIDUAL FUNCTIONS

L DIAGRAM MODEL 1015

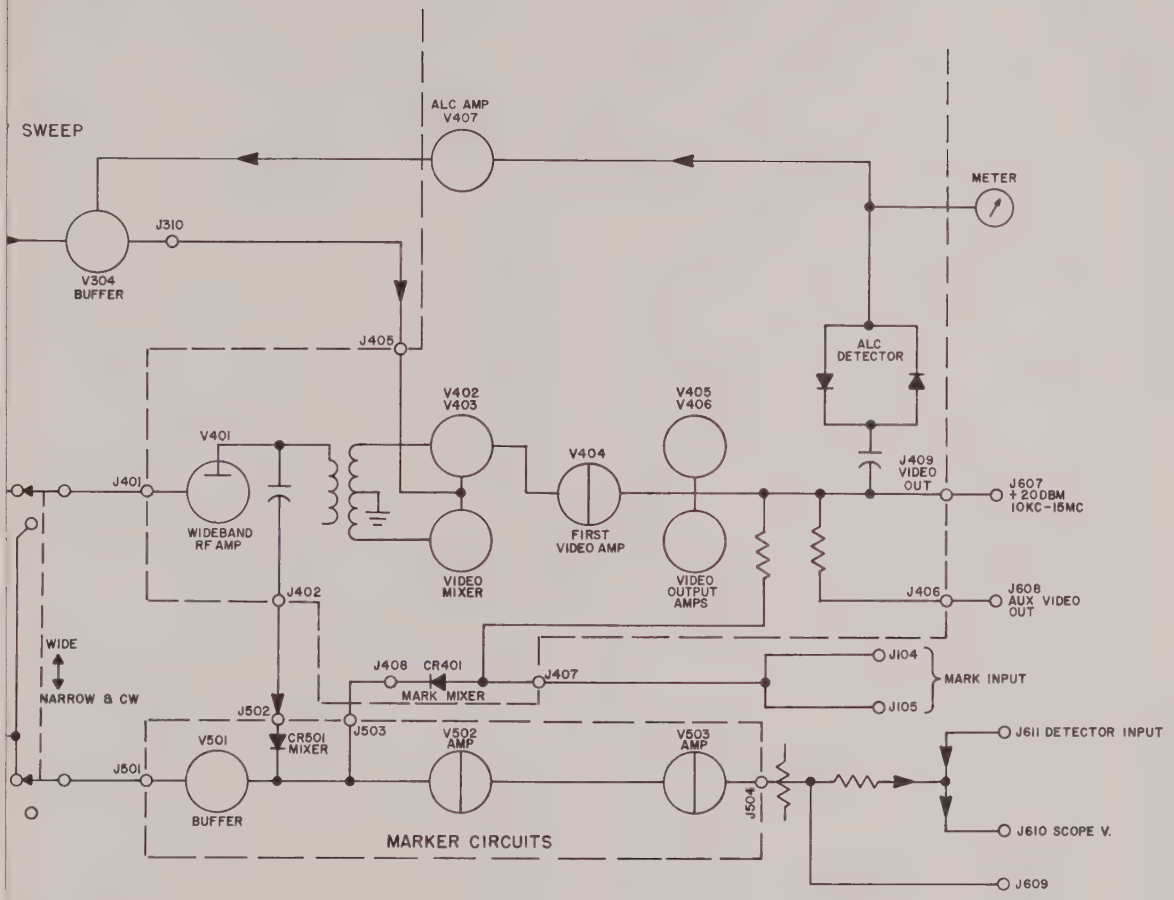
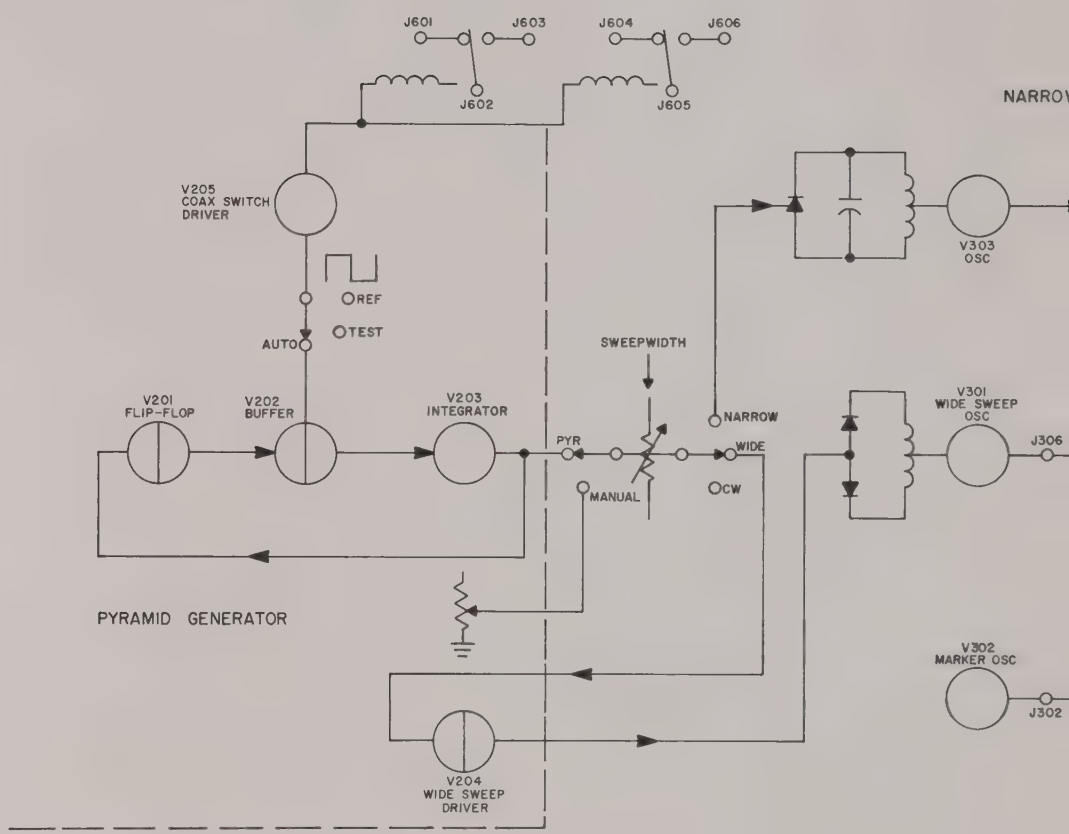


FIG. 1 FUNCTIONA



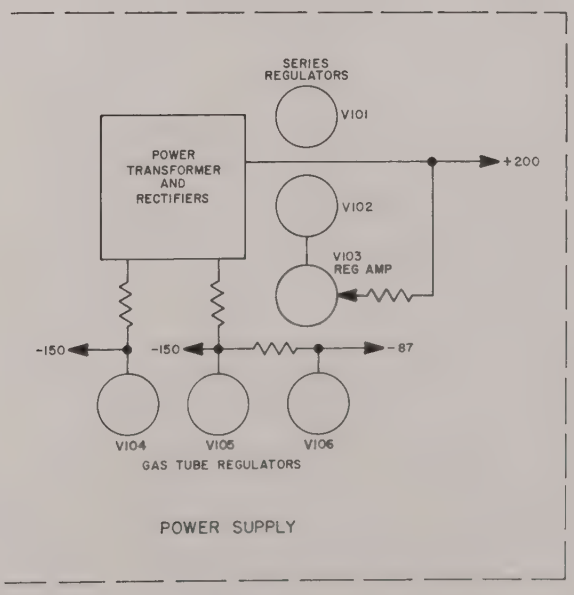
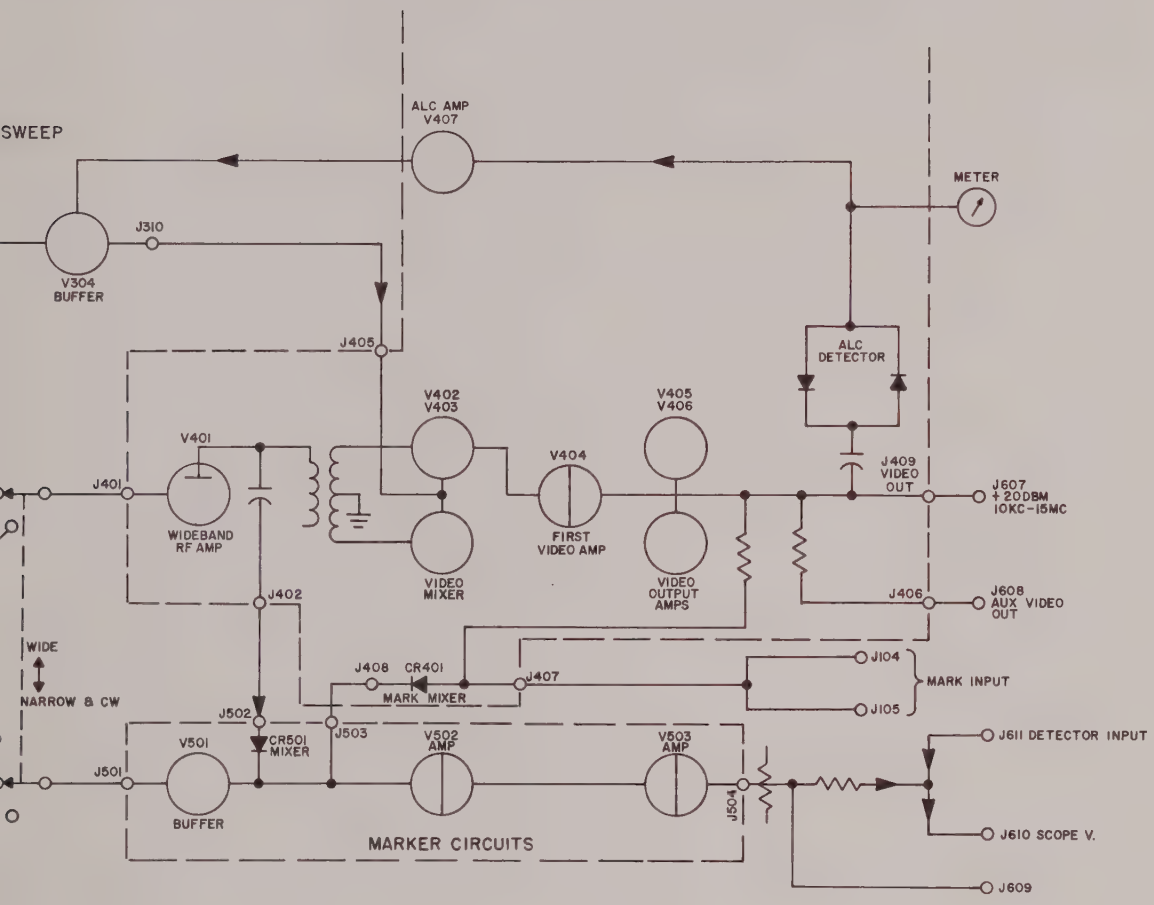


DIAGRAM MODEL 1015



CIRCUIT DESCRIPTION

GENERAL (refer to Fig. 1 Functional Diagram of Model 1015)

Model 1015 uses the beat-frequency principle, employing two oscillators to obtain a video frequency output variable between 1 kc and 15 mc. One oscillator operating at 55 mc beats with a second oscillator which sweeps down from 55 to 40 mc, to produce the difference frequency.

Three modes of operation are available: WIDE SWEEP, NARROW SWEEP, and CW. In all three modes the 55 mc signal is generated by the narrow sweep oscillator V303, coupled through a buffer V304 to the video mixer stage V402, V403. In the WIDE SWEEP condition, the 55 to 40 mc signal is provided by the wide sweep oscillator V301, amplified by the wide band r-f amplifier V401 and fed to the video mixer. In the NARROW SWEEP condition, oscillator V301 is disabled, the 55 to 40 mc signal being provided by the marker oscillator V302 whose frequency is manually tunable over this range of frequencies. To obtain narrow sweep widths (up to 200 kc) the 55 mc narrow sweep oscillator is frequency-modulated. For CW operation this modulation is removed.

The two beating signals are mixed in the video mixer V402, V403; its output is then amplified by a two-stage video amplifier V404, V405, V406, and supplied at high level to the video output terminal. The video output level is sampled by the ALC detector employing CR402, CR403, which feed a d-c correcting voltage back through the ALC amplifier V407, to control the bias and thus the output signal from the narrow sweep buffer V304. The ALC detector also feeds the output meter.

In the WIDE SWEEP condition, the output of the marker oscillator is connected through a buffer V501 to a mixer diode CR501, where it beats with a sample of the 55 to 40 mc sweep. The resulting marker signal is amplified by V502 and V503 and then added to the detector output to form a "birdie" marker on the scope screen. The marker output is also available from the MARKER OUT fitting J609 for input to the oscilloscope "Z" axis to generate intensity frequency markers. Outputs from external marker generators are mixed with the video output in the external marker mixer CR401 and amplified by the same marker amplifier V502 and V503.

The wave form which sweeps the frequency of Model 1015 is generated by the pyramid generator, consisting of: a flip-flop V201, a buffer V202, and an integrator V203. These act together to generate a pyramid wave form with excellent linearity, covering a range of sweep rates from 1 sweep per 2 1/2 minutes up to 60 sweeps per second. A switch permits the selection of either this wave form for continuous automatic sweeping, or of the d-c output from a potentiometer for manually varying the sweep rate over the same range. Either of these outputs is applied through the sweep width control to the appropriate oscillator.

In the WIDE SWEEP condition an additional amplifier V204 is used for obtaining sufficient voltage swing to drive voltage-variable capacitors (varactor diodes) in the wide-sweep tuned circuit over their full range of capacitance.

To allow the use of the "measurement by comparison" technique (see Jerrold Technical Newsletter Vol. 2 No. 1) a square-wave output from the pyramid generator is applied through the coaxial switch driver V205 to a set of coaxial relays forming a double-pole double-throw coaxial switch, which is thus driven synchronously with the pyramidal horizontal deflection.

The power supply uses silicon diode rectifiers, source regulators V101 and V102, a regulator amplifier V103, and three gas tube regulators V104, V105 and V106.

THE PYRAMID GENERATOR (see basic circuit diagram Fig. 2)

The function of the pyramid generator is to provide a voltage which varies at a constant rate, rising to +40 volts and falling to zero. The generator employs a Miller integrator V203 to produce a constant current which is fed into a capacitor. The resulting constant-slope wave form is connected back to a flip-flop V201, which switches at the upper and lower limits to reverse the direction of charge.

During the forward trace the first section of V201 is cut off, the second section conducts, lowering the output voltage of the cathode follower buffer V202A to its lower limit of -18 volts. The charge on the capacitor and the voltage on the grid of V203A fall towards this level. This change is amplified by the two sections of V203 and applied to the opposite side of the sweep capacitor, the amplifier acting to hold the current through the capacitor constant and thus maintaining a linear voltage variation with time.

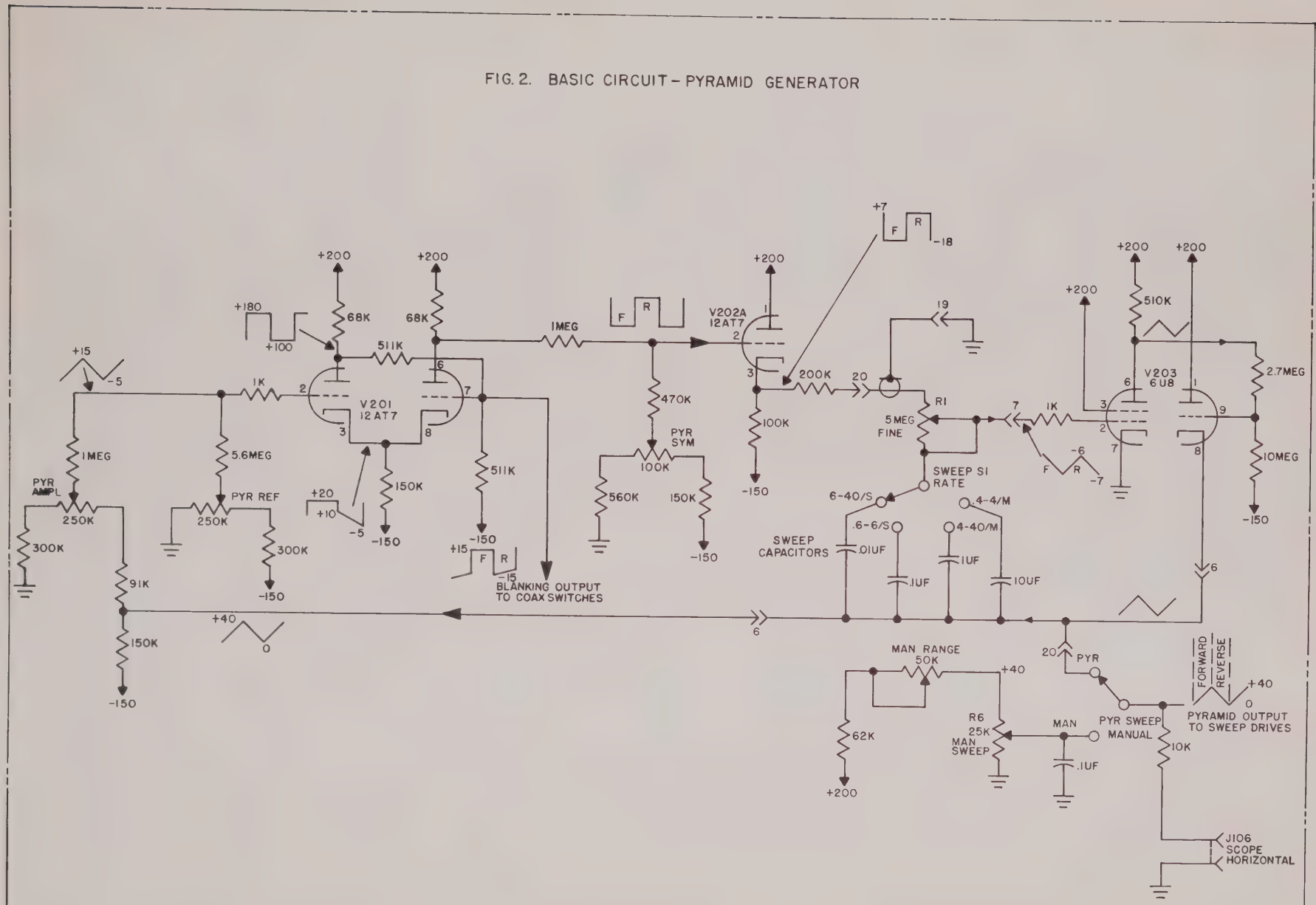
The flip-flop V201 is designed so that it switches when the grid voltage of the first section rises to +15 volts, and switches back when that voltage falls to -5 volts. To operate this flip-flop from the pyramid output which varies between 0 and +40 volts, amplitude and d-c level adjustments are required. These are provided by the resistor networks associated with the Pyramid Amplitude and Pyramid Reference controls.

As the output voltage rises to +40, the grid voltage of V201A rises. When it reaches +15 volts (which is the cut-off voltage since the cathode of this section is at +20 volts) the tube starts to conduct. The flip-flop then switches, causing the second section to cut off, driving the output of V202A to +7 volts and causing a reversal in the direction of voltage change on the sweep capacitor; the grid voltage of V203A rises towards -6 volts as the pyramid output falls towards zero. When it reaches zero, the flip-flop hits its lower switching voltage, it flops back and the cycle is repeated.

The rate at which the charge is applied to the capacitor, and thus the sweep repetition frequency, is controlled by the FINE SWEEP RATE potentiometer R1 and by the SWEEP RATE switch S1 which connects one of four decaded capacitors for selection of the desired range of sweep rate. A Pyramid Symmetry control R207 permits adjustment of the average level on the grid of the buffer V202A to obtain equal forward and return sweep periods.

When the PYR SWEEP - MANUAL switch S5 is thrown to MANUAL position, output voltage is obtained through the MANUAL SWEEP control R6. This potentiometer is adjusted for a maximum output of +40 volts. Since the output voltage, is somewhat affected by the resistance of the scope input, this adjustment should be made with the scope connected. All controls in the pyramid generator are factory-adjusted so the pyramid covers the same 0 to +40 volt range as the output of R6.

FIG. 2. BASIC CIRCUIT – PYRAMID GENERATOR



THE WIDE SWEEP OSCILLATOR (see basic circuit diagram Fig. 3)
This oscillator is designed to produce an output with frequencies varying from 55 down to 40 mc in response to a varying d-c input. A twin-triode V301 is arranged in a Colpitts oscillator circuit, with the two tube sections in parallel for maximum transconductance, and with the tube's capacitances swamped out by large shunt capacitors C347 and C348. The oscillator coil is physically separated from the oscillator tube by short coaxial cable jumpers to provide thermal isolation for maximum stability. The coil is wound in two sections on a grooved ceramic form, the output being inductively coupled through J306 to the wide sweep r-f amplifier V401.

Two varactor diodes C361 and C362 control the oscillation frequency. Their capacitance varies from about 10 pf to about 30 pf as the applied bias varies between 80 volts and 30 volts. The frequency corresponding to the low beat frequencies is chosen at the upper frequency limit of this oscillator where the varactor diodes have maximum bias, since greatest frequency stability is obtained under this condition.

The varying bias voltage for these varactor diodes is supplied by the wide sweep driver V204 in the pyramid generator. This driver amplifier uses d-c degeneration to provide a precise relationship between the pyramid drive voltage and the varactor diode bias. The WIDE SWEEP CENTER FREQ control R3 allows varying the average bias so that, at relatively narrow sweep widths, the average frequency can be positioned anywhere within the 55 to 40 mc range.

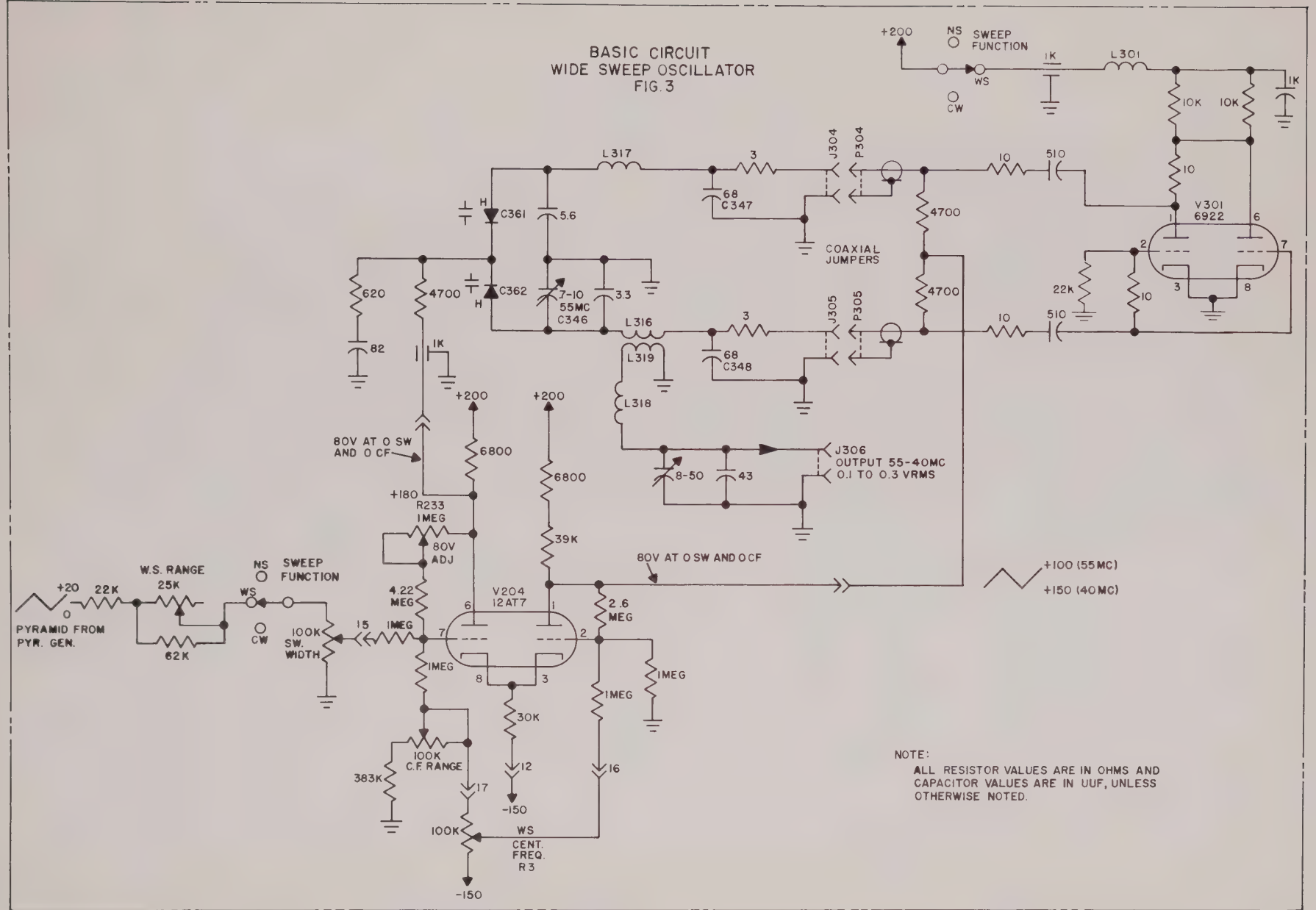
To prevent the possibility of voltage breakdown, the "80 V ADJ" pot. R233 is factory-set so that the varactor diode bias is 80 volts, with the SWEEP WIDTH and WIDE SWEEP CENTER FREQ controls set at 0 (zero). The oscillator is then trimmed to 55 mc by C346 so that, as the SWEEP WIDTH control is turned up, the low end of the sweep stays at zero beat while the upper limit frequency increases toward 15 mc.

THE NARROW SWEEP OSCILLATOR (see basic circuit diagram Fig. 4)
This oscillator uses a circuit similar to that of the wide sweep oscillator. A single varactor diode C360 is connected in such a way that it has only a small effect on frequency, providing a maximum deviation of ± 200 kc from the 55 mc center frequency.

When the function switch is set to the NARROW position, the SWEEP WIDTH control is connected so that it varies the pyramid voltage applied across C360. A fixed bias of 87 volts is applied across C360, since maximum stability is obtained under this condition. In the CW position the 87 volts remain, but the pyramid voltage is removed so there is no frequency modulation.

The output voltage from the oscillator grid is coupled to a pentode buffer amplifier V304 which isolates the oscillator and produces a means for controlling the gain in response to the varying d-c voltage from the ALC circuit.

THE MARKER OSCILLATOR (see basic circuit diagram Fig. 5)
This oscillator uses a circuit similar to the wide sweep oscillator circuit, but with its frequency controlled by a rotary variable capacitor connected to the front panel dial. Careful design, rigid construction and a ceramic coil form insure stable operation and accurate dial calibration. Trimmer C354 and coil L323 are factory-adjusted for 55 mc and 40 mc respectively, setting the upper and lower marker frequency limits.


BASIC CIRCUIT
WIDE SWEEP OSCILLATOR
FIG. 3
+200
NS
SWEEP FUNCTION
WS
CW
1K
L301
10K
10K
1K
10
V301
6922
L317
3
J304
P304
10
510
68
C347
C361
5.6
4700
COAXIAL JUMPERS
620
4700
C362
7-10
55MC
C346
3.3
22K
82
1K
L316
3
J305
P305
10
510
L319
68
C348
L318
+200
+200
80V AT O SW AND O CF
6800
6800
J306
OUTPUT 55-40MC
0.1 TO 0.3 VRMS
8-50
43
+180
R233
1MEG
80V
ADJ
39K
80V AT O SW AND O CF
+100 (55MC)
+150 (40MC)
W.S. RANGE
25K
NS
SWEEP FUNCTION
+20
22K
WS
4.22
MEG
V204
12AT7
2.6
MEG
PYRAMID FROM PYR. GEN.
62K
CW
100K
SW.
WIDTH
15
1MEG
1MEG
1MEG
30K
100K
C.F. RANGE
383K
12
16
17
-150
100K
WS
CENT.
FREQ.
R3
-150
NOTE:
ALL RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN UUF, UNLESS OTHERWISE NOTED.

SCHEMATIC
NARROW SWEEP
OSCILLATOR & BUFFER
FIG. 4

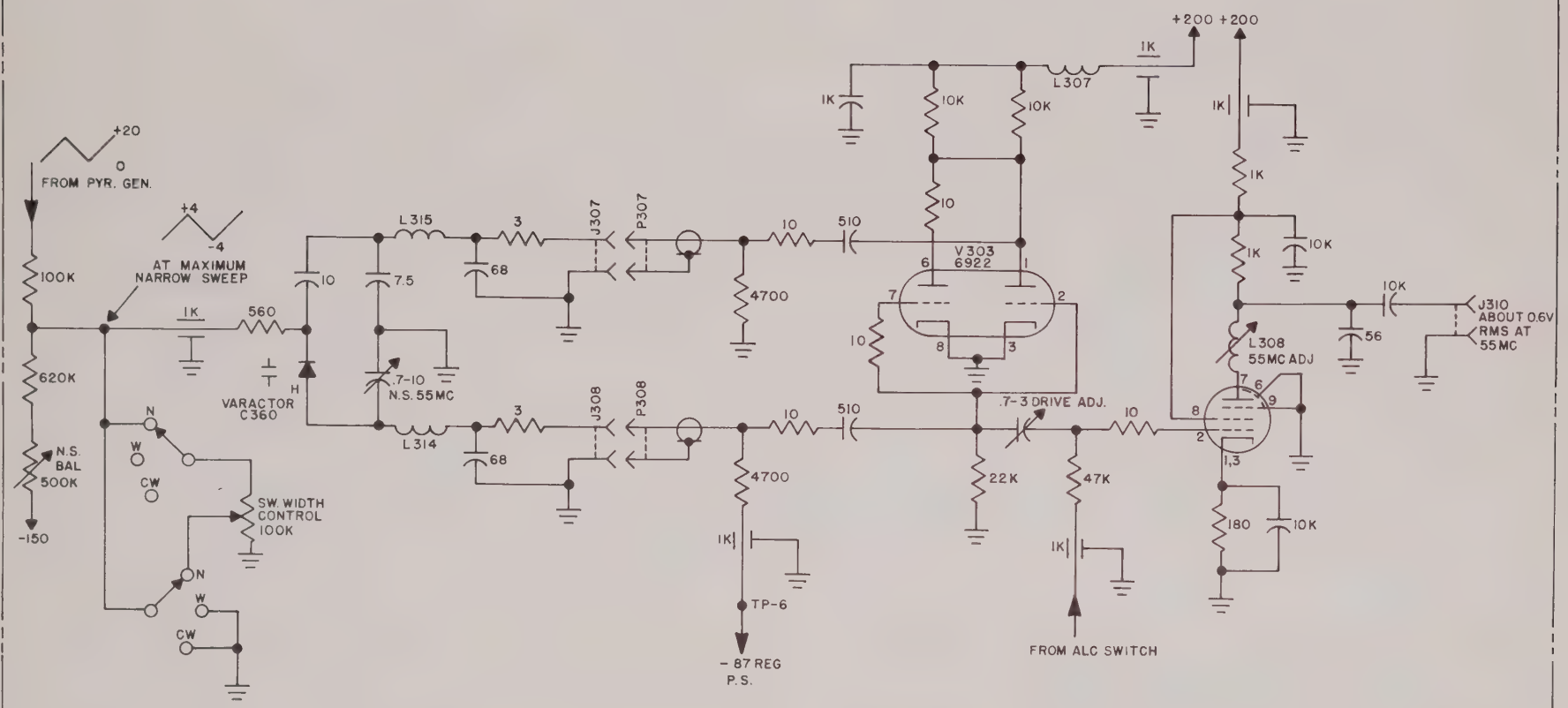
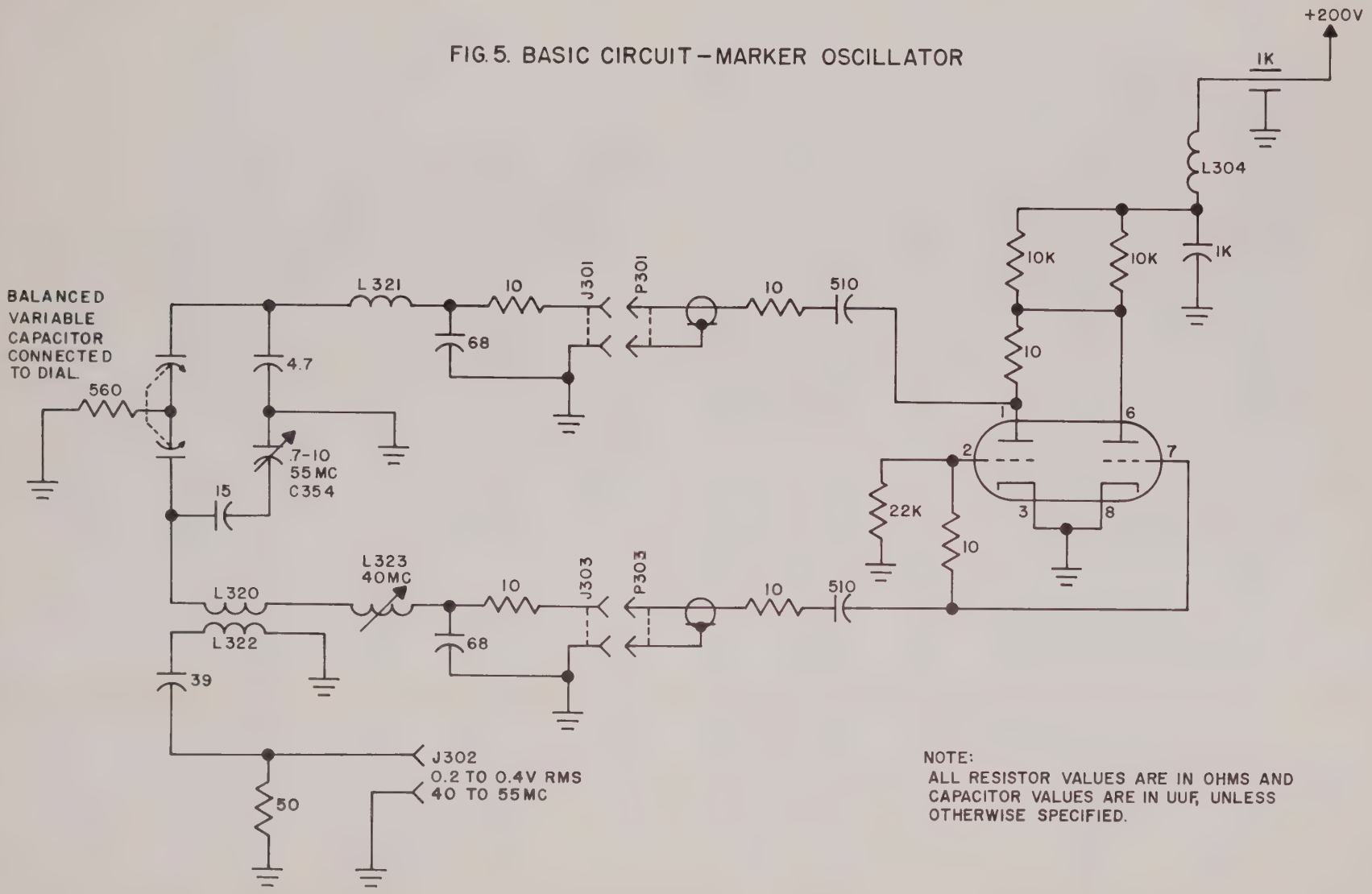


FIG. 5. BASIC CIRCUIT – MARKER OSCILLATOR



NOTE:
ALL RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN UUF, UNLESS OTHERWISE SPECIFIED.

THE MIXER AND VIDEO AMPLIFIER STAGE

Two different mixer designs have been used in Models 1015. Series A, B and C up to unit Serial No L238C have the following circuitry (see basic circuit diagram Fig. 6 (A)

The output of the wide sweep oscillator (in the WIDE sweep mode) or of the marker oscillator (in the NARROW sweep or CW mode) is amplified by a high-gain pentode V401 and applied symmetrically to the two grids of a balanced mixer stage V402 and V403. The input network is a double-tuned circuit providing optimum impedance match at the input terminal over the frequency range 40 to 55 mc. The network between the plate of V402 and the mixer grids is triple-tuned, showing a typical three-peaked response over this band of frequencies. An inductively coupled transformer T401 serves for accurately balancing the voltages on the two grids.

The 55 mc input from the narrow sweep oscillator is stepped up by transformer L401 and coupled through capacitor C410 to the mixer cathodes.

The use of a balanced mixer has several advantages basic to the performance of Model 1015. A primary advantage is the reduction of even-order harmonics in the beat frequency output. It also provides inherent isolation between the two driving sources, so that extremely low difference frequencies can be used without danger of lock-in. Meticulous factory-alignment of the wide sweep drive level pot. R404, the mixer balance pot. R412, and the mixer bias control R416 assure mixer operation with minimum distortion in the output signal.

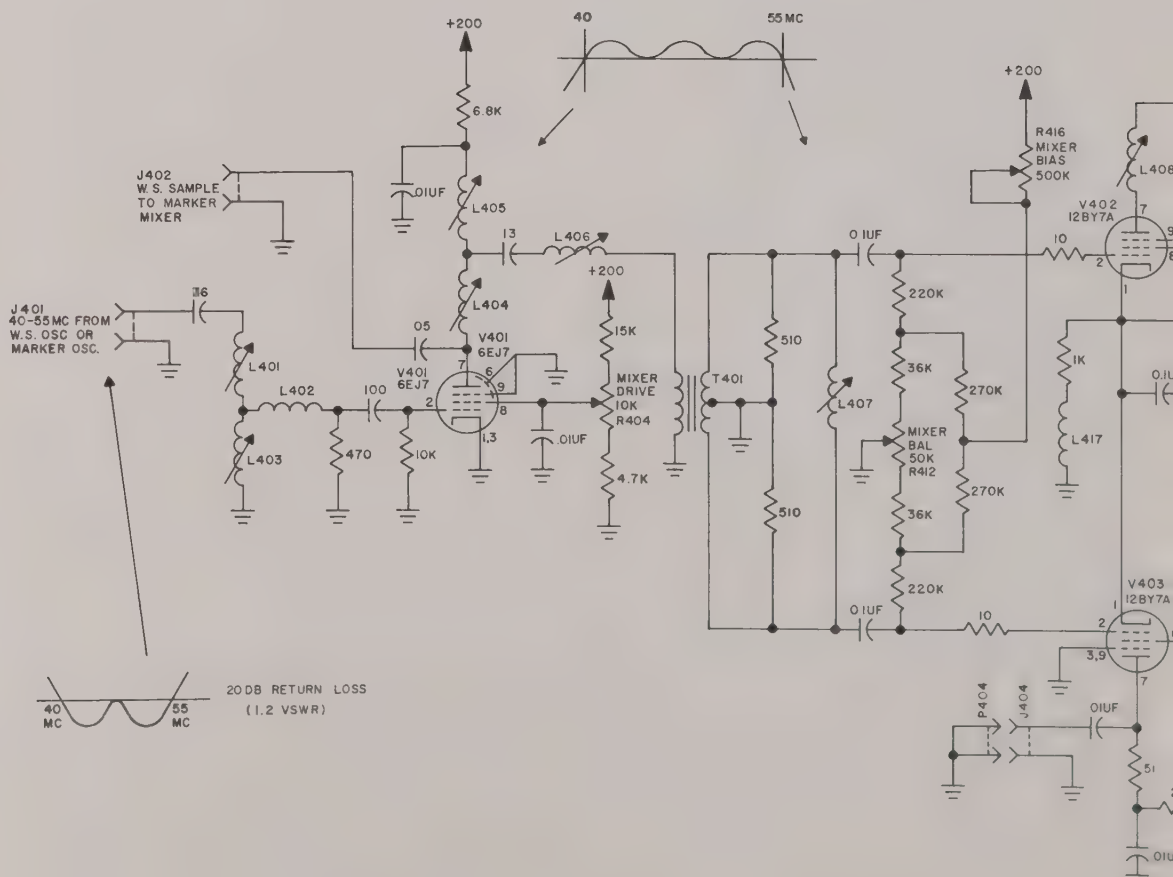
Although the video output comes from the plate of only one tube V402, full advantage of the balanced configuration is taken because of the degeneration provided by the high impedance through R473 and L417 between the two cathodes and ground.

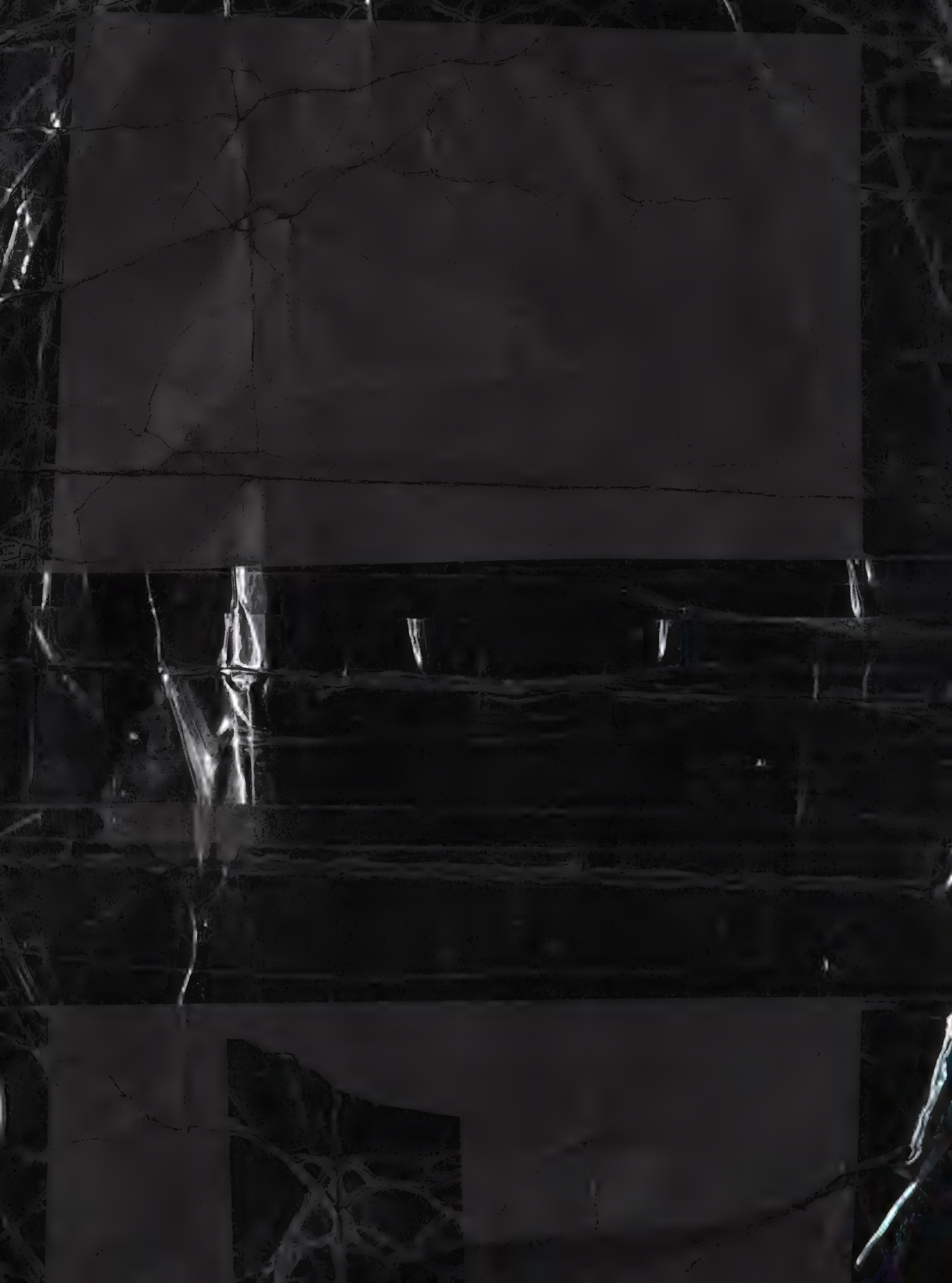
The network in the plate circuit of V402 forms a low-pass filter having maximum flat response out to 15 mc and cutting off rapidly above that frequency. The network couples the beat frequency output to the grid of the buffer stage V404. Although this stage has no voltage gain, its use is essential in that its input capacity is about half that of the output stage, affording a 2:1 increase in the impedance level of the video filter. The two triodes of V404 are arranged in a cascode circuit providing low output impedance as well as cancellation of even-order distortion products. The output of the buffer is directly coupled to the grid of V405 in the output stage.

The output stage employs two high-current beam power pentodes V405 and V406 in a cascode circuit similar to the buffer circuit, for delivering a maximum output voltage within the set distortion limits. The arrangement of inverse feedback from the plate of V405 to the grid of V406 results in a very low output impedance; proper impedance match is obtained by resistor R450 connecting the output to the VIDEO OUT terminal J409. In 50-ohm impedance Models 1015 this resistor is 50 ohms; in 75-ohm versions it is 75 ohms.

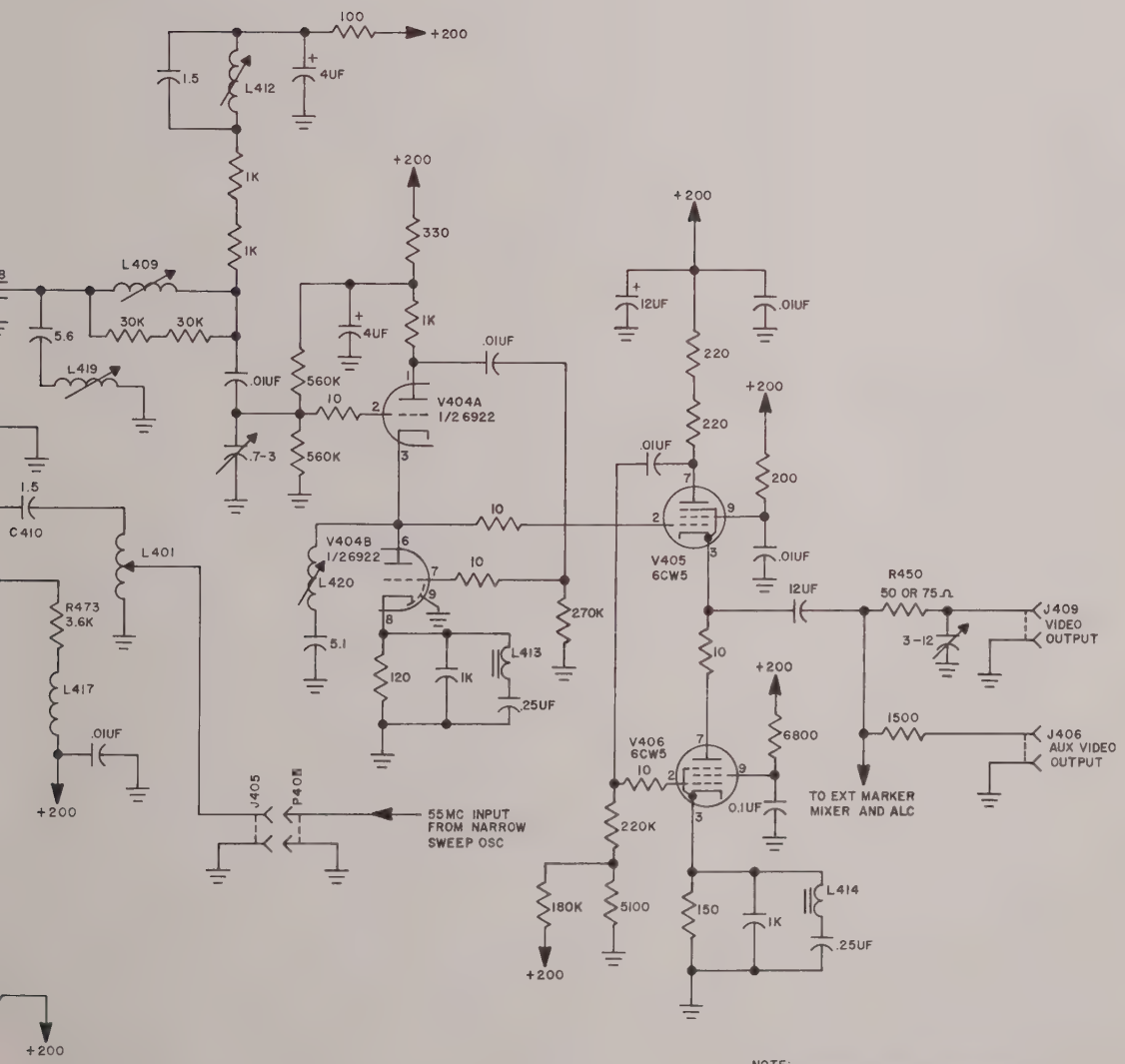
In addition, a low-level auxiliary video output is available through 1500-ohm resistor R451 connected to AUX VIDEO terminal J406.

FIG. 6(A) BASIC CIRCUIT – MIXER





ND VIDEO AMPLIFIER (EARLY UNITS)



NOTE:
ALL RESISTOR VALUES IN OHMS AND
ALL CAPACITOR VALUES IN UUF, UNLESS
OTHERWISE NOTED.

MODIFIED MIXER AND VIDEO AMPLIFIER STAGE

(see basic circuit diagram Fig. 6(B)

This modification applies to Models 1015, Series D, unit Serial No. L239D and above.

In these instruments the pentode balanced mixer is replaced with a mixer using four matched diodes in a ring circuit. Also, the wide sweep buffer, instead of a 6EJ7, now uses a 12BY7 which affords a higher drive level to the mixer. The diodes are driven by the wide sweep signal to about 15 milliamperes d-c. Test points TP1 and TP2 permit measurement of the d-c drive level. The 55 mc signal is introduced at low level on the center tap of T401.

The beat frequency output of the mixer is coupled through a low pass filter to the grids of V402 and V403, which convert this push-pull signal into a single-ended output. Grid bias adjustment on both tubes permits minimizing the distortion contributed by this stage.

The remainder of the circuitry in the mixer and video amplifier stage is the same as in Series A, B and C.

THE ALC CIRCUIT (see basic circuit diagram Fig. 7)

The function of this circuit is to keep output level variations to less than 0.15 db from low frequencies up to 15 mc.

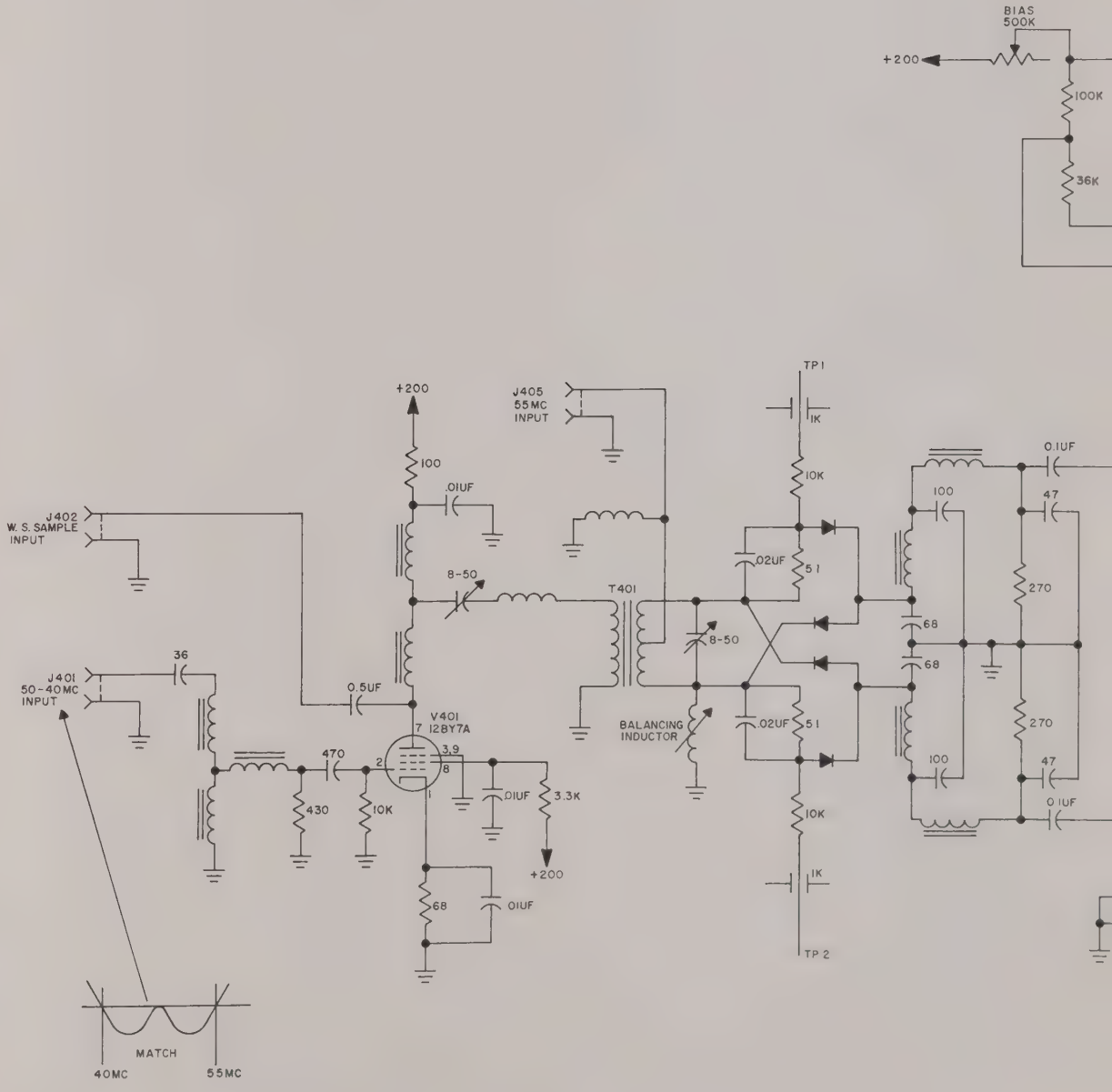
An r-c network connects the output of the last video amplifier to the ALC rectifiers CR402 and CR403. The network shapes the voltage supplied to these detectors in such a way that the resulting correction achieves the desired flatness. The network compensates for variations in detector response with frequency and reduces the drive voltage to a level within the rating of the diodes used. Capacitor C430 acts as a tilt control, raising or lowering the high-frequency output relative to the low-frequency output.

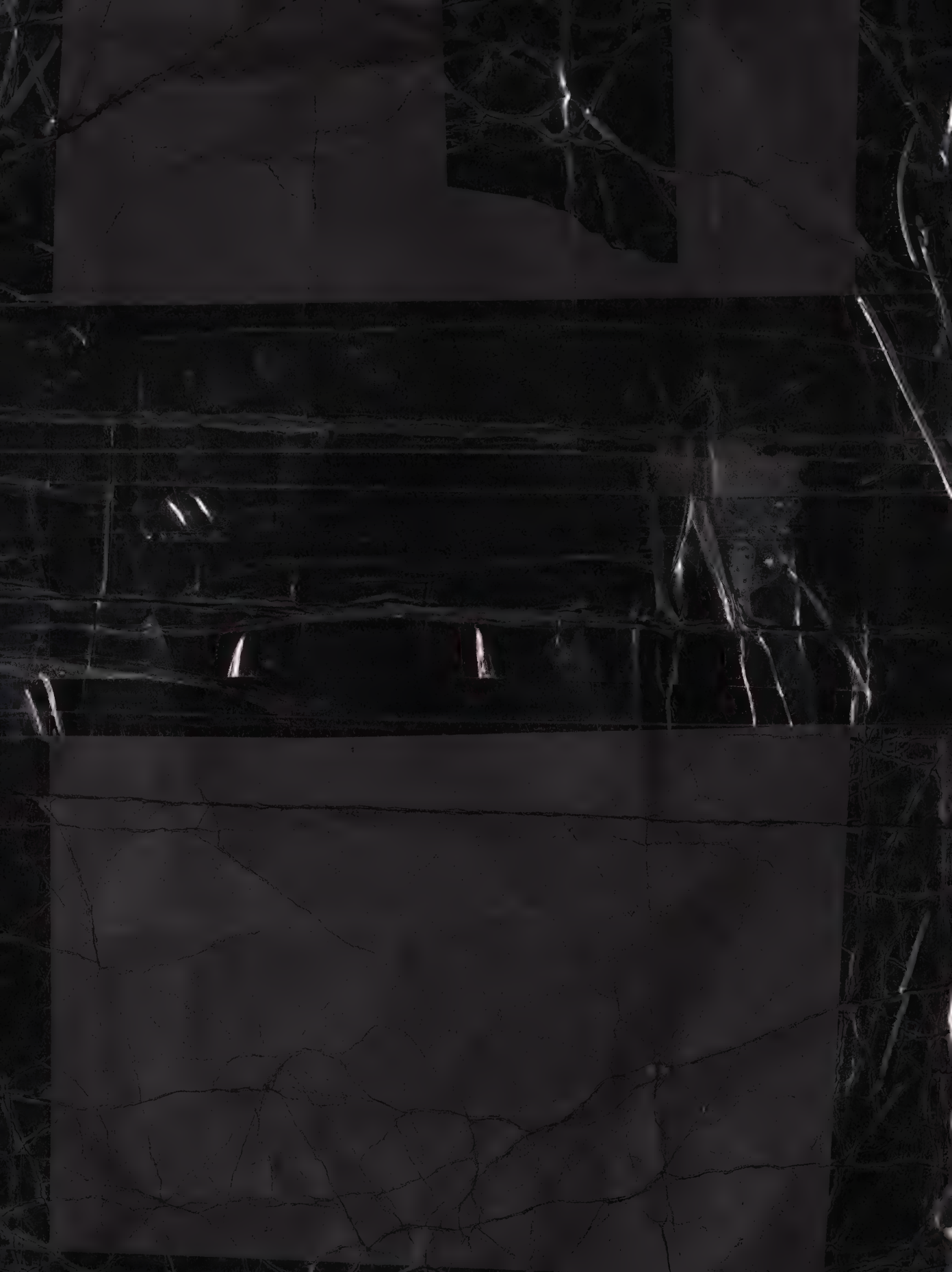
The detectors operate in a full wave voltage averaging circuit. Their output current flows through the panel meter calibrated to indicate output level; the output voltage is applied to the input of the d-c amplifier V407. The resulting varying d-c output is passed from the plate of the pentode section to the narrow sweep buffer, where it achieves the gain control necessary to level the output. Diode CR404, connected from plate to ground, prevents the ALC output from going positive, which might harm the buffer tube.

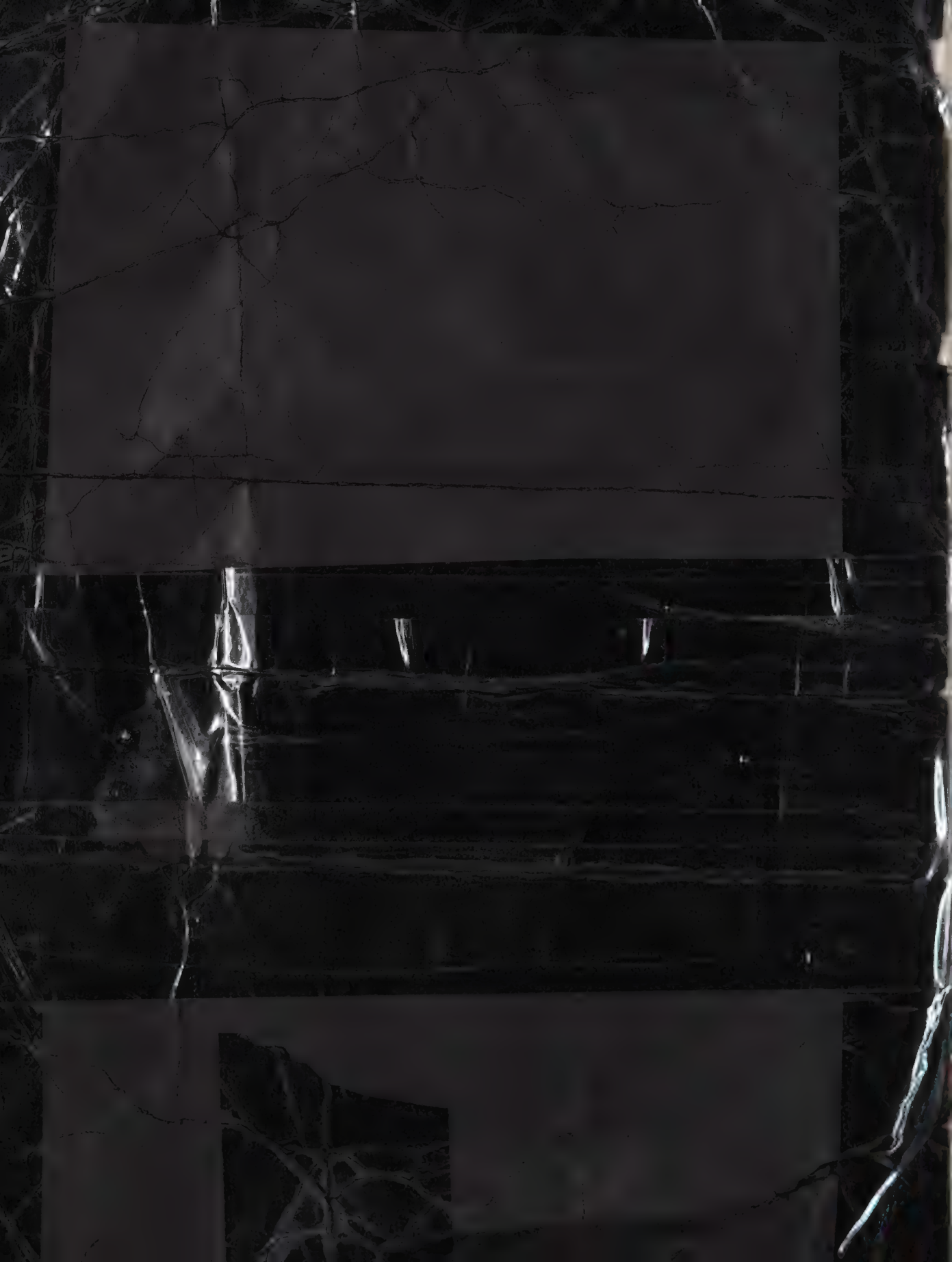
The time constants in the detector filter make the ALC circuit effective down to about 20 kc; but at frequencies lower than that there is a leakage of video signal through the ALC channel causing output distortion.

To allow satisfactory operation in the lowest decade, an ALC ON-OFF push-pull switch S6 is provided via the shaft of the front panel OUTPUT LEVEL control; the switch permits disabling the ALC circuit and manually controlling the narrow sweep buffer bias and thus the output level.

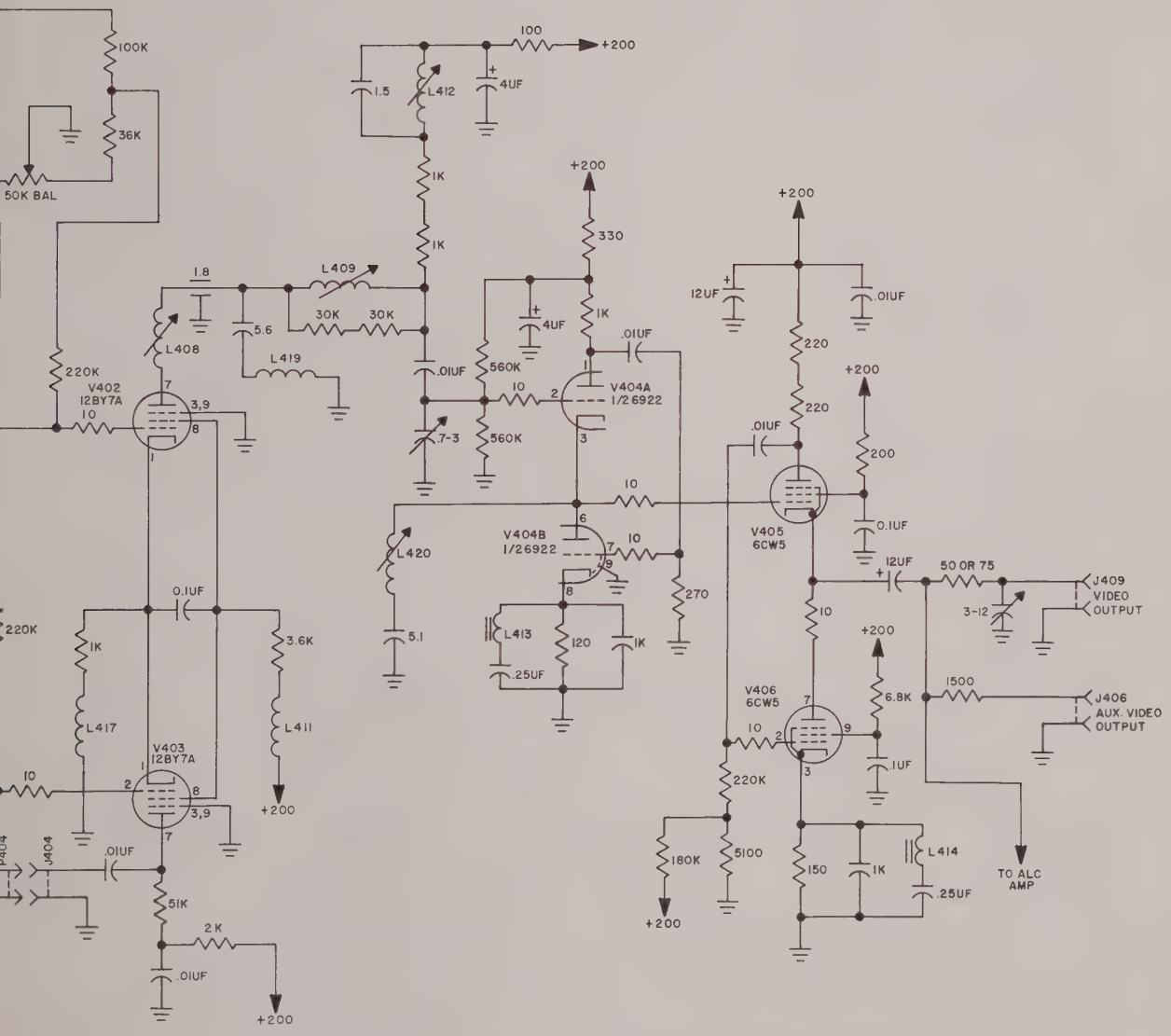
FIG.6(B). BASIC CIRCUIT – MIXER AND VID



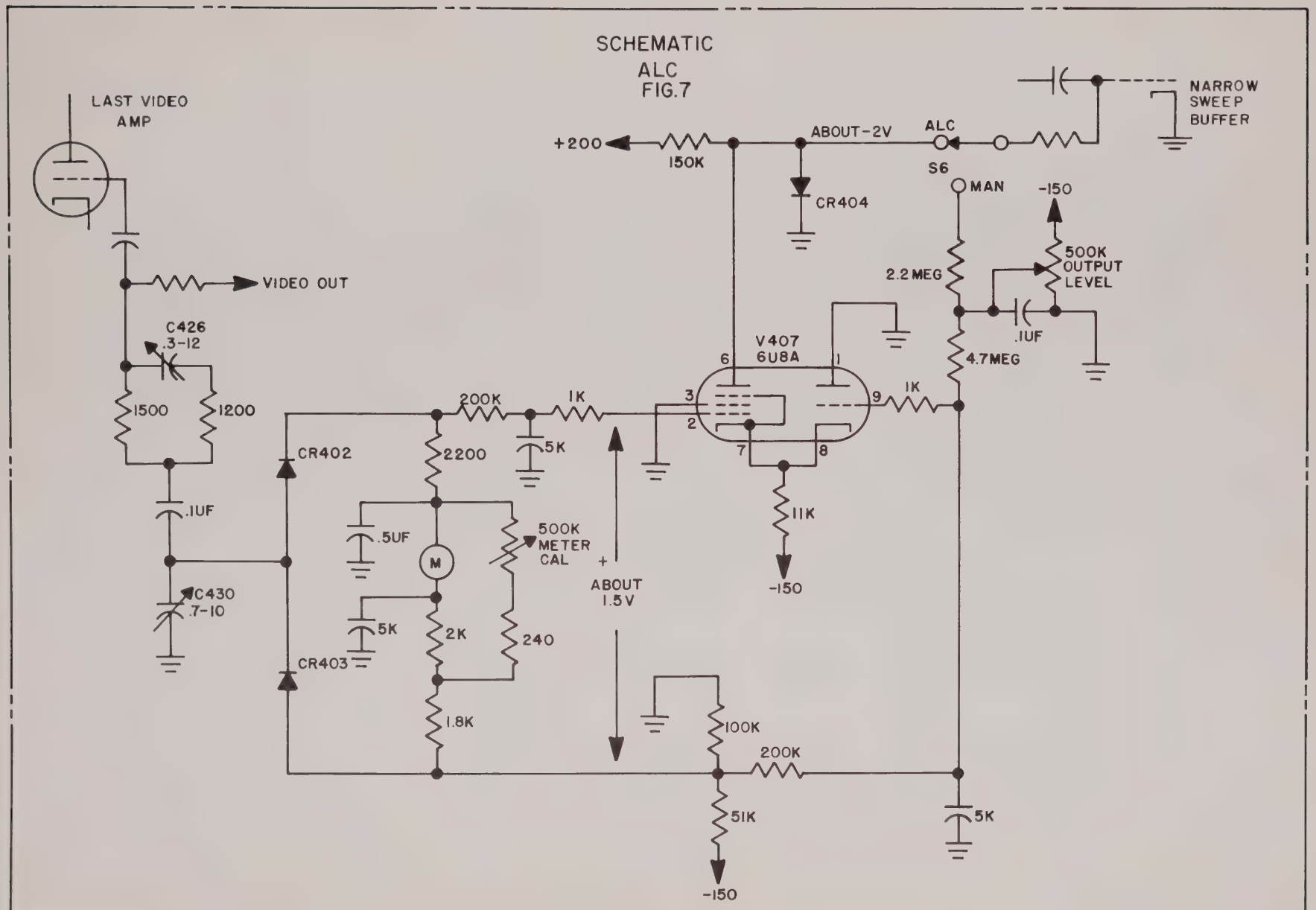




O AMPLIFIER (MODIFIED UNITS)



NOTE.
ALL RESISTOR VALUES ARE IN OHMS AND
ALL CAPACITOR VALUES ARE IN UUF, UNLESS
OTHERWISE NOTED.


SCHEMATIC
ALC
FIG.7
LAST VIDEO AMP
+200
150K
ABOUT-2V
ALC
S6
MAN
-150
NARROW SWEEP BUFFER
CR404
2.2MEG
500K OUTPUT LEVEL
.1UF
4.7MEG
VIDEO OUT
C426 .3-12
V407 6U8A
6
1
3
2
9
7
8
1K
200K
1K
1500
1200
2200
5K
CR402
.1UF
.5UF
M
500K METER CAL
+
ABOUT 1.5V
11K
-150
C430 .7-10
5K
2K
240
CR403
1.8K
100K
200K
51K
5K
-150

THE FREQUENCY MARKER CIRCUITS (see basic circuit diagram Fig. 8)
These circuits permit frequency marking, both from the built-in marker oscillator and from one or two external marker oscillators.

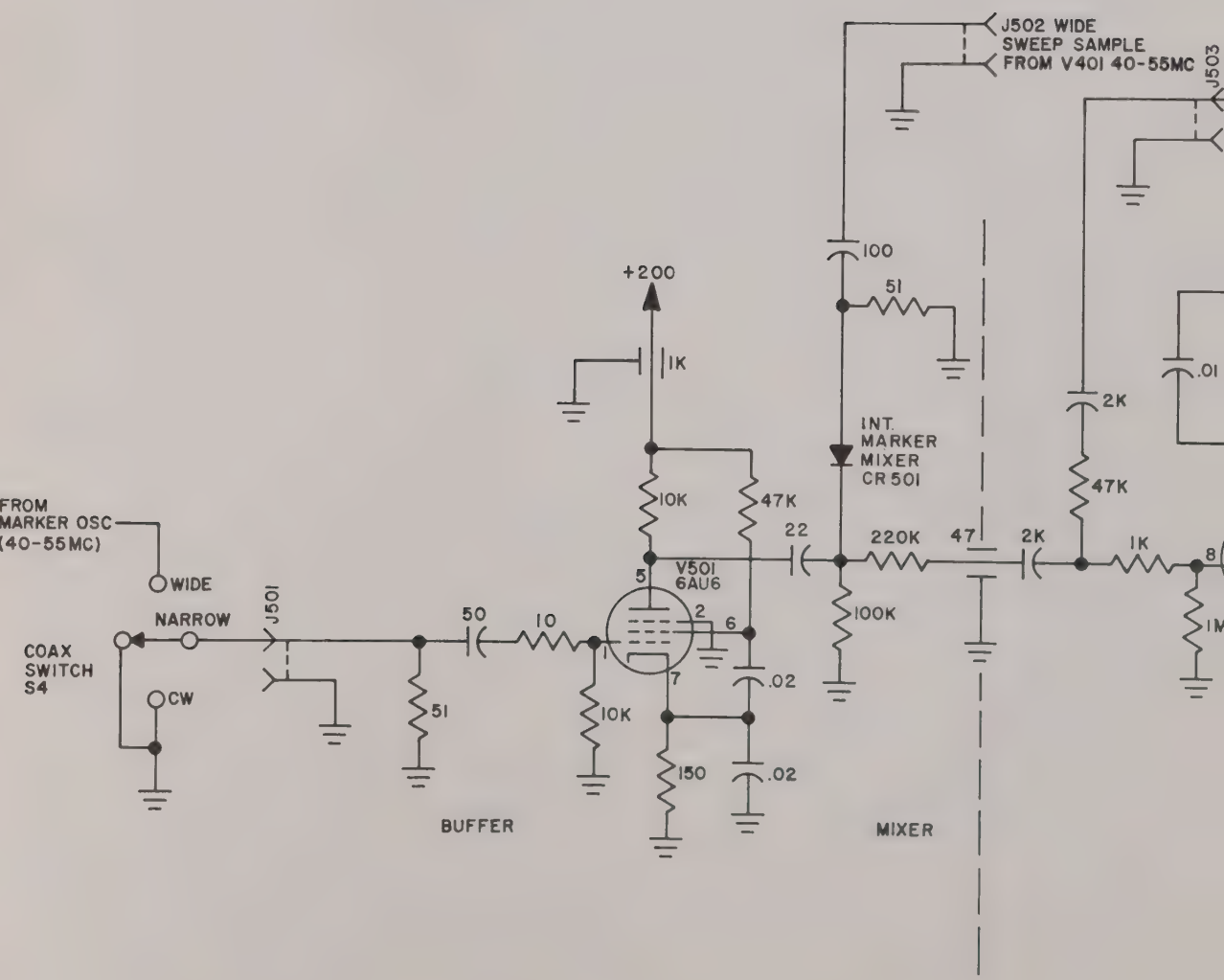
With the function switch in WIDE position, the output of the internal marker oscillator, tunable over the range from 40 to 55 mc, is connected to the input of the marker amplifier V501. Its output in turn is passed to the marker mixer CR501 where it is mixed with a sample of the wide sweep signal obtained from the plate circuit of V401. The output of CR501 has a difference frequency which goes through zero beat at the time the sweep oscillator frequency passes the frequency to which the marker oscillator is set. This beat is applied to the input of V502A, a high-gain amplifier pentode with its plate circuit tuned to approximately 7 kc. This signal is further amplified by V502B and V503. The level of the resulting output is controlled by MARKER GAIN potentiometer R2 and connected to the MARKER OUT terminal J609 and the VERT SCOPE terminal J610.

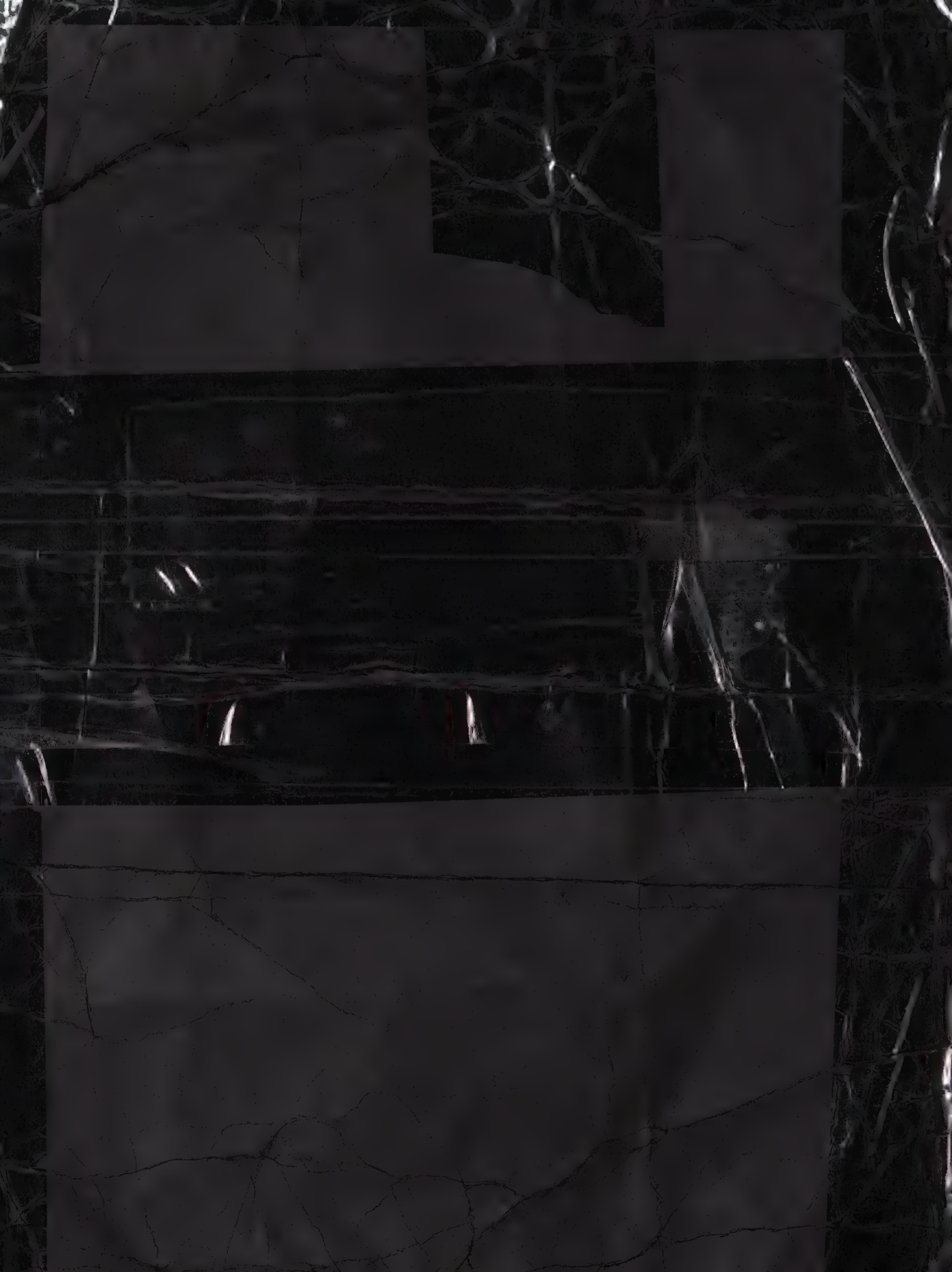
When the external detector signal is brought in through EXT DET INPUT terminal J611, with the scope vertical connected to terminal J610, the marker signal is mixed with the detector output, producing a "birdie" marker on the scope trace.

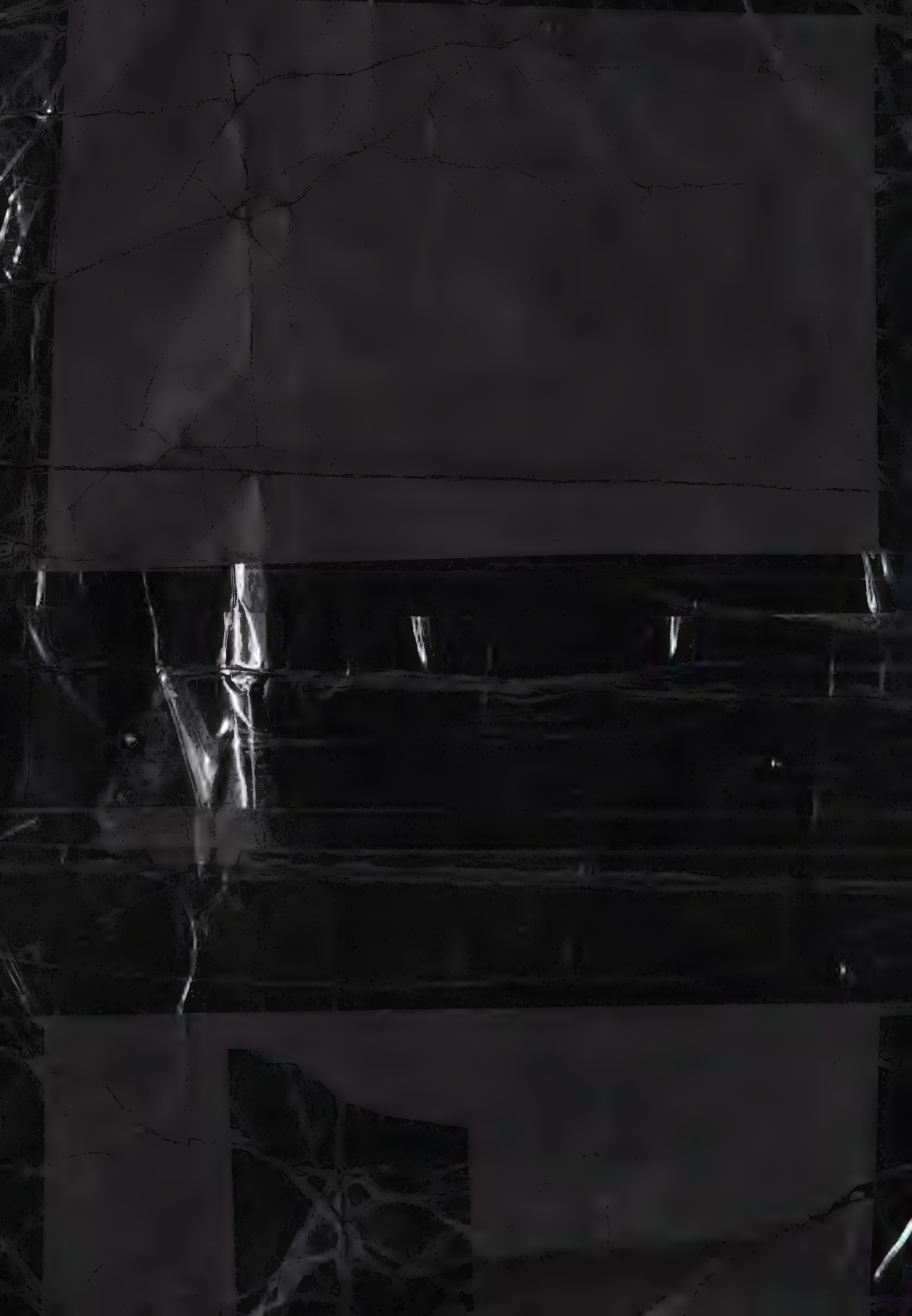
EXT MARKER INPUT terminals J104 and J105 permit connection of external marker generators. Signals introduced at that point are applied to the external marker mixer CR401, where they are mixed with a sample taken from the video output. When the frequency of the video output passes the frequency of an external oscillator, a beat is generated which is amplified by the marker amplifier as described above and then appears as a "birdie" marker on the scope trace.

Since the marker amplifier is tuned to approximately 7 kc, the resulting "birdie" will occupy approximately 28 kc on the trace. For narrow sweep applications, the "birdie" bypass system is unsatisfactory and must be abandoned for some other measuring system, such as a direct readout counter operated from the AUX VIDEO output terminal J608.

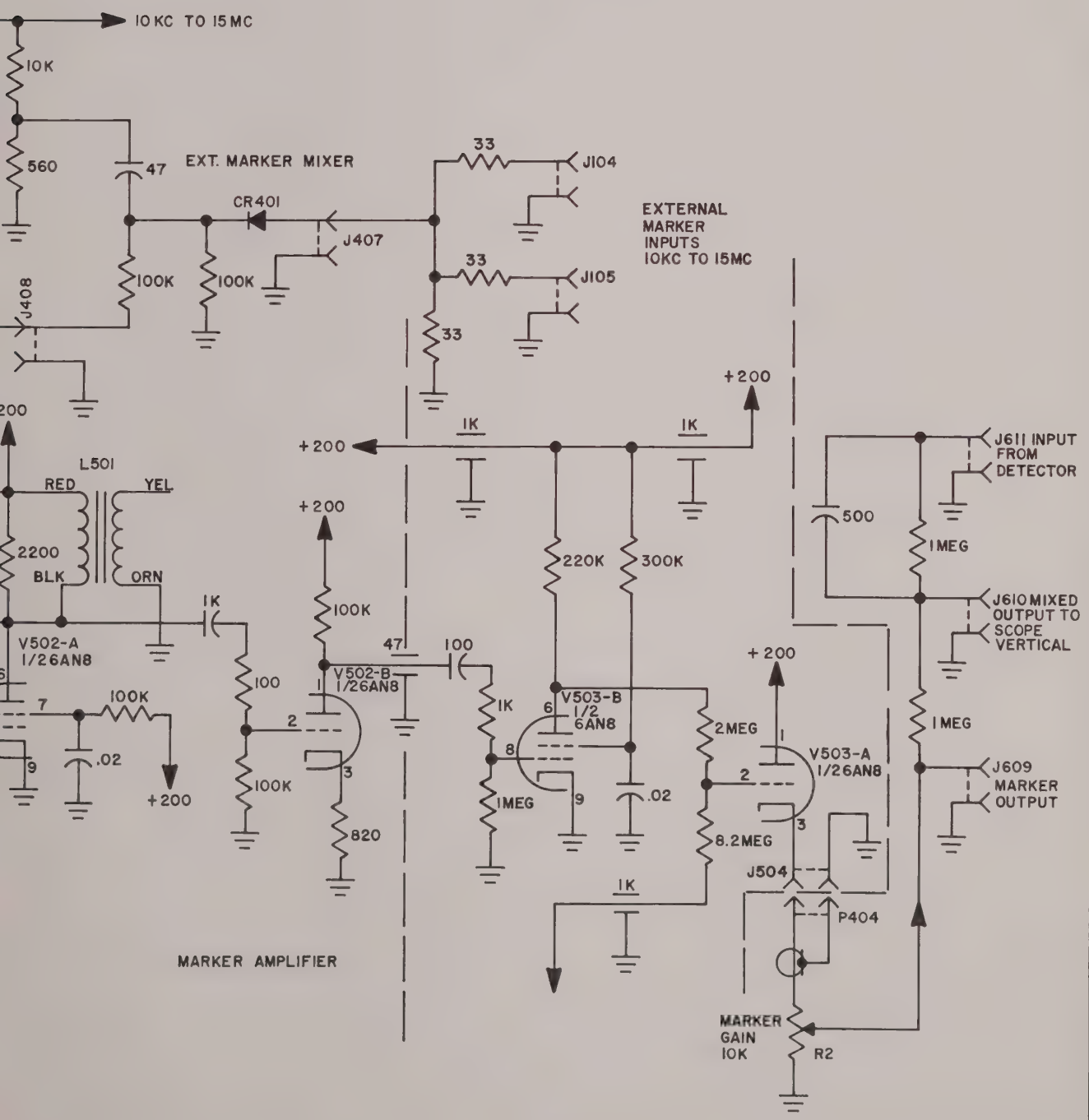
SCH
FREQUENCY







MATIC
RKER CIRCUITS
G.8



THE COAXIAL SWITCHERS

Series A and B instruments incorporate a coaxial switcher employing six mercury-wetted contact relays (see basic circuit diagram Fig. 9A). These are connected to form two single-pole double-throw coaxial switches with additional relays employed for providing a termination on the unused input as well as for increasing the isolation between used and unused circuits. These switches are driven by a square-wave voltage taken from the pyramid generator. This voltage is applied to the grid of V202B, driving its cathode to +20 volts during the forward trace and to -10 volts during the return trace. This cathode voltage is connected to J107 through an isolating resistor to form the blanking output.

Current for the relay coils is provided by the switch driver V205. With switch S2 in REF position, the grid of V205 is connected to -150 volts and its plate current is zero. In this condition the relays are idle, with their respective "IN" circuits connected to their "REF" circuits. When S2 is thrown to TEST position, the grid of V205 is grounded through R246, full plate current flows and the six relays are actuated, connecting to the TEST circuit.

When S2 is set to AUTO, the output of V202B is applied to the grid of V205, driving it to full plate current for the TEST condition during the forward trace, and cutting it off for the REF condition during the return trace.

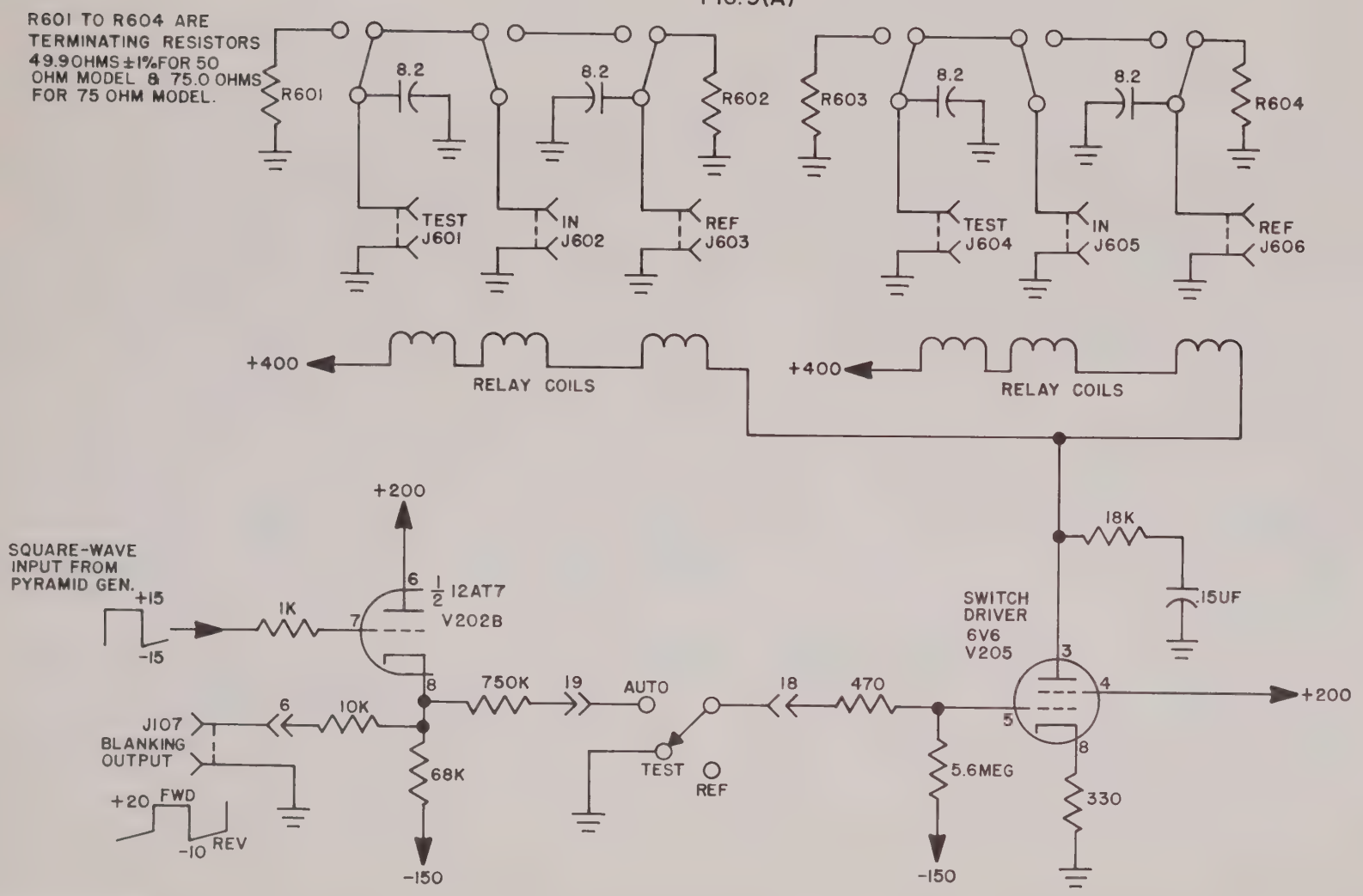
Series C and D instruments use reed relays for coaxial switching in place of the mercury-wetted type (see basic circuit diagram Fig. 9B). The reed relays operate considerably faster, so that switching at the higher sweep speeds is accomplished much closer to the edge of the scope screen. The circuit operation is similar to that described for the mercury-wetted relays, except that the reed relays are single-pole units, and their idle state is with contacts open; current must be supplied to close each set of contacts, as required. Two output currents are provided by a twin-triode switch driver V205; one current is delivered by V205A during the forward trace to give the TEST condition, the other current is provided by V205B during the return trace to give the REF condition.

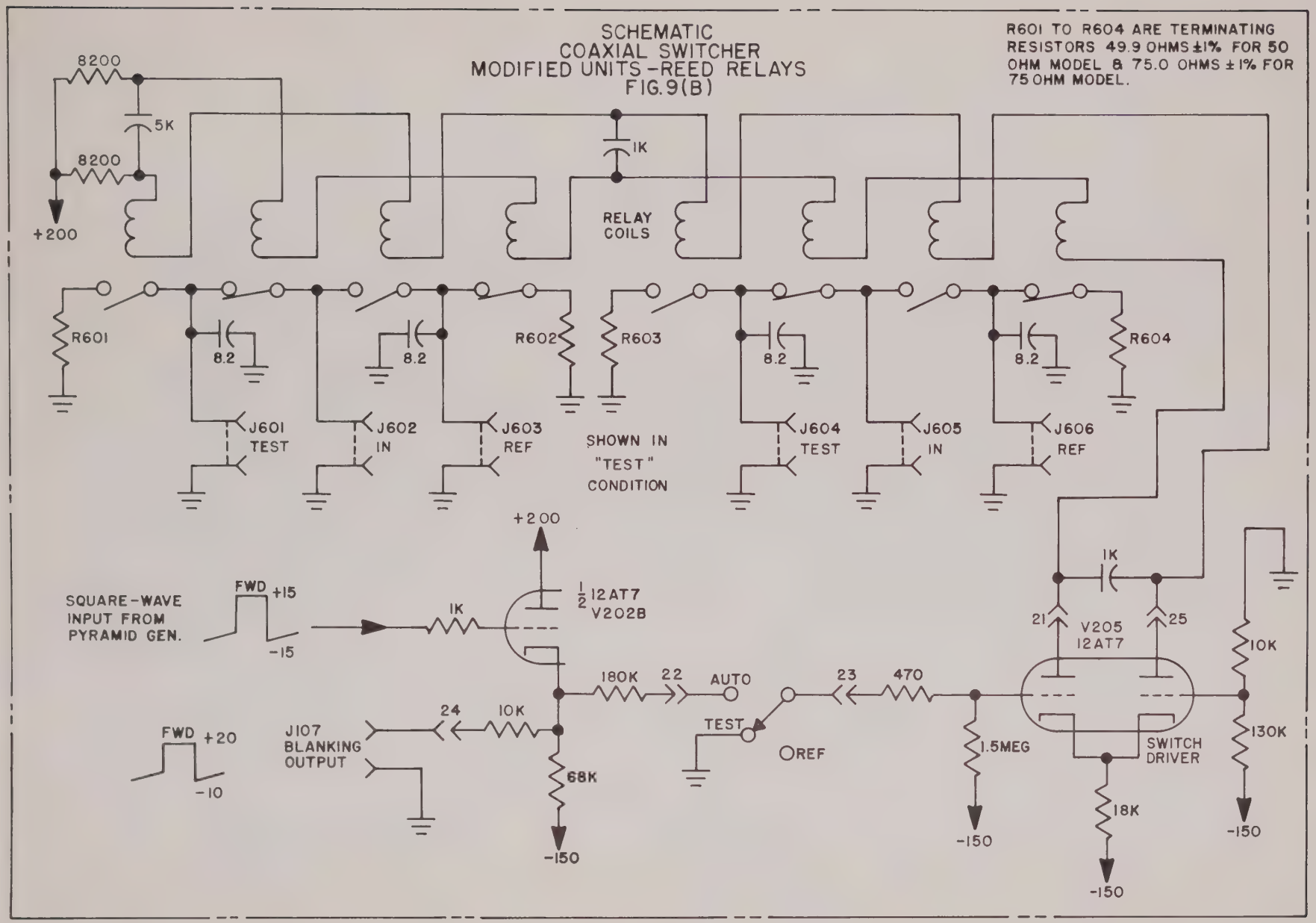
THE POWER SUPPLY (see basic circuit diagram Fig. 10)

Power input is via front panel POWER switch S3 and fuse F101 to transformer T101 which can be wired for either 115 or 230 vac 50-60 cps. The T101 secondary windings provide two 6.3 vac outputs at high current for the tube heaters. Both these windings are operated with grounded center taps to minimize hum. The high voltage output is rectified by one pair of silicon diodes CR102 and CR104 to drive two gas tube voltage regulators V104 and V105 providing two independently regulated -150 volt supplies. A third regulator tube V106 is fed from V105 to provide a doubly-regulated -87 volt bias supply for the varactor diodes in the narrow sweep oscillator and as a reference for the series regulator. The latter employs two beam power pentodes V101 and V102 fed from rectifiers CR101 and CR103 and a regulator amplifier V103 to supply a regulated +200 volts output controlled against the -87 v reference. RIPPLE BAL potentiometer R108 affords balancing adjustment for minimum 120-cycle ripple in the output.

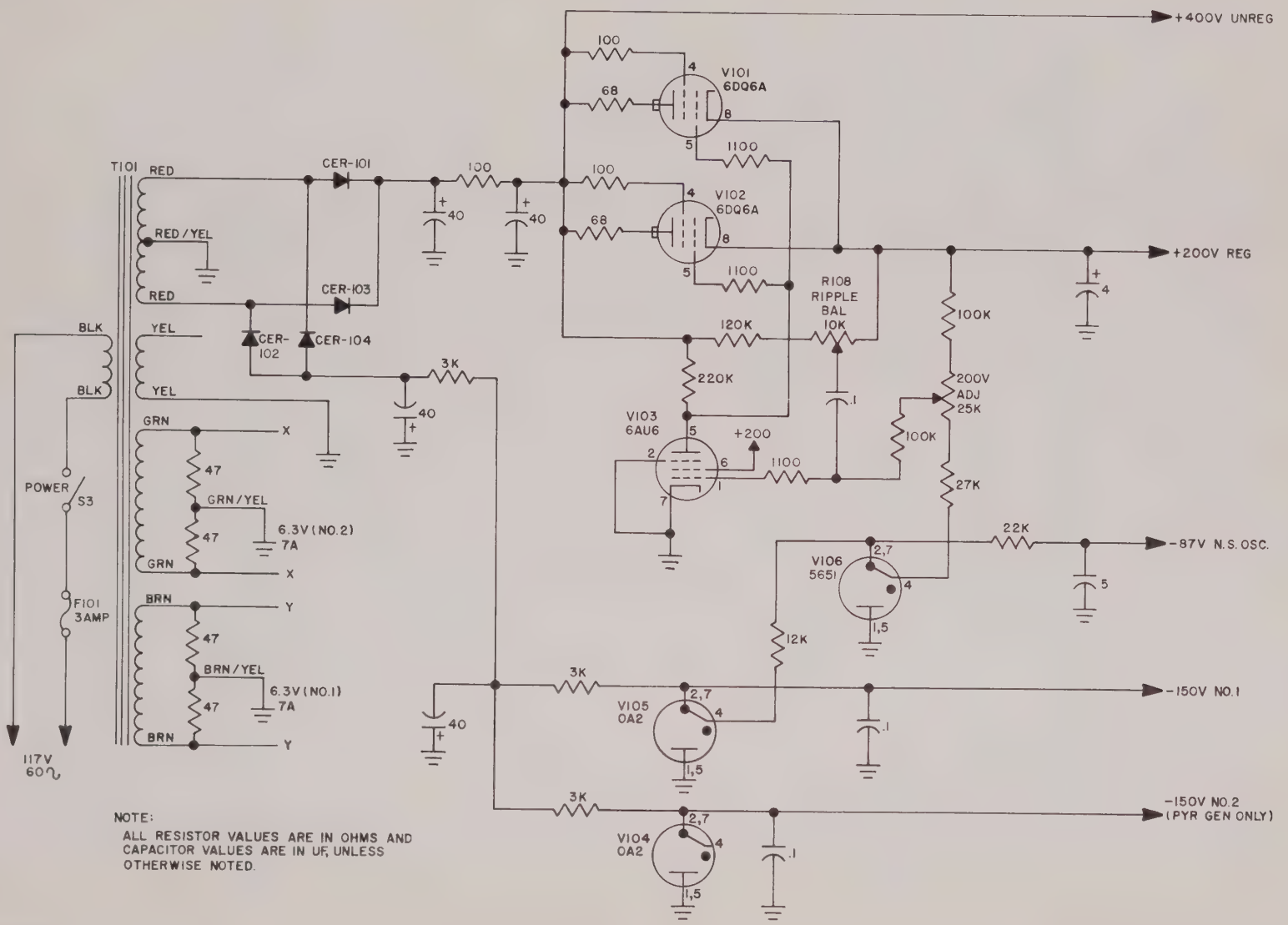
A 9-pin tube socket at the rear apron of the main chassis provides test points for all power supply output voltages except the heater supplies.

SCHEMATIC
COAXIAL SWITCHER
ORIGINAL MODEL-MERCURY RELAYS
FIG. 9(A)




SCHEMATIC
COAXIAL SWITCHER
MODIFIED UNITS -REED RELAYS
FIG. 9(B)
R601 TO R604 ARE TERMINATING RESISTORS 49.9 OHMS ±1% FOR 50 OHM MODEL & 75.0 OHMS ±1% FOR 75 OHM MODEL.
8200
5K
8200
+200
1K
RELAY COILS
R601
8.2
R602
8.2
R603
8.2
R604
8.2
J601 TEST
J602 IN
J603 REF
SHOWN IN "TEST" CONDITION
J604 TEST
J605 IN
J606 REF
+200
SQUARE-WAVE INPUT FROM PYRAMID GEN.
FWD +15
-15
1K
½ 12AT7 V202B
1K
21
V205 12AT7
25
10K
180K
22
AUTO
23
470
24
10K
FWD +20
-10
J107 BLANKING OUTPUT
TEST
REF
68K
1.5MEG
SWITCH DRIVER
130K
18K
-150
-150
-150
-150

BASIC CIRCUIT
POWER SUPPLY
FIG. 10



NOTE:
ALL RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN UF, UNLESS OTHERWISE NOTED.

INITIAL CHECK-OUT

GENERAL

1. When unpacking the equipment, check that no damage has been caused in transit. Insure that all tubes are properly seated, that the fuse is in place and that no other damage is apparent.
2. The check-out procedure given here will assure that the equipment is in proper operating condition. This procedure is also recommended as a 3-monthly routine maintenance check.
3. Proper impedance matching of equipment and leads used in the test set-up is essential.
4. Equipment required:

    a. VTVM . . . Hewlett-Packard Model 410B, or equivalent.
    b. Laboratory type oscilloscope.
    c. Video Detector . . . Jerrold Model D-12-5B

CHECK-OUT PROCEDURE

1. Set up equipment as shown in fig. 11.

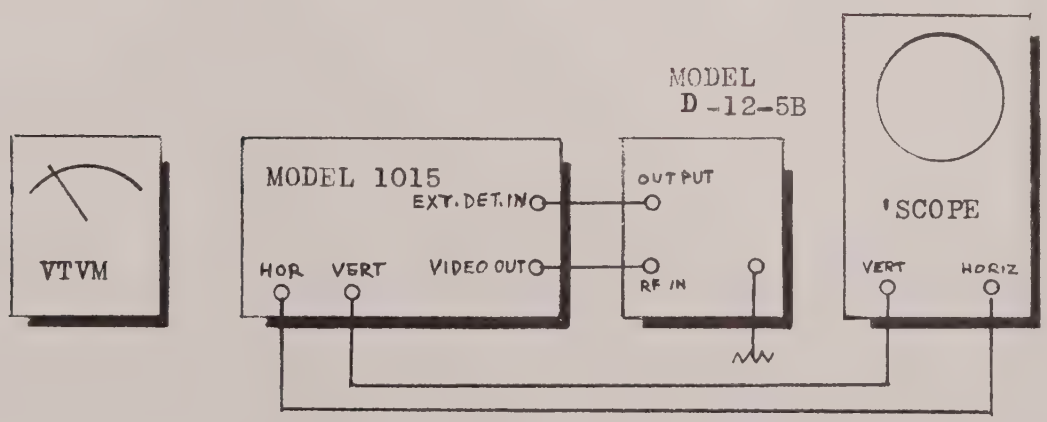


Fig. 11 TEST SET-UP FOR INITIAL CHECK

2. Switch on all instruments and allow 30 minutes for warm-up.

3. Set controls on Model 1015 as follows:

CONTROL	POSITION
WIDE SWEEP CENTER FREQ.	0 (zero)
SWEEP FUNCTION	CW
SWEEP WIDTH	0 (zero)
SWEEP RATE	SW/SEC 6-60
FINE	mid-range
PYR SWEEP - MANUAL	PYR SWEEP
ALC	ON (knob pushed in)
MARKER GAIN	minimum (full ccw)
COAX SWITCHER	REF
Logging control	full ccw, placing pointer at left end of scale

4. A tube socket marked TEST POINTS is available at the rear apron of the main chassis. Connect the positive probe of the VTVM to pin #1 and the negative probe to pin #5 of the socket. If the VTVM reading is outside the range of 76 to 84 vdc, align the pyramid generator as described in the maintenance section of this manual. Disconnect the VTVM probes.
5. Adjust oscilloscope for d-c input; adjust horizontal sensitivity for full deflection; adjust vertical sensitivity for full scale deflection as controlled by the oscilloscope HORIZ. SIGNAL.
6. Set OUTPUT LEVEL control on Model 1015 to obtain a 20 db indication on the front panel output meter.
7. Turn the logging control slowly clockwise until the oscilloscope displays a zero beat. The inset dial between upper and lower logging scale should read 10 (± 1) and the pointer on the upper logging scale should be on 0 (zero). If the inset dial reads other than 10 (± 1), set the dial to read 10 and adjust the NS55MC trimmer on the oscillator coil chassis to obtain the zero beat on the oscilloscope. If this cannot be accomplished, align the pyramid generator as described in the maintenance section.
8. Set SWEEP FUNCTION switch to NARROW position; zero beat on the 'scope should be approximately at center of display.
9. Set SWEEP FUNCTION switch to WIDE position. If the zero beat display disappears from the 'scope screen, adjust both the SWEEP WIDTH control and the SWEEP CENTER FREQ. control to bring zero beat back onto the screen. If the markings on either control read greater than 2 at the return of zero beat, set both controls to 0; then adjust the WS55MC trimmer on the oscillator coil chassis to obtain zero beat on the 'scope. If this cannot be accomplished, align the pyramid generator as described in the maintenance section.

10. Turn the SWEEP WIDTH control fully clockwise. The oscilloscope should - if necessary by adjusting the WIDE SWEEP FREQ control - display full sweep, with the zero beat positioned at the extreme left of the screen.
11. Turn the MARKER GAIN control to maximum (full clockwise) and set pointer on upper frequency scale to 15 mc. The marker should be positioned on the extreme right of the 'scope screen; if not, or if off the screen, align the pyramid generator as described in the maintenance section.
12. Turn the MARKER GAIN control slowly counter-clockwise; the marker amplitude should decrease.
13. Set the PYR SWEEP MANUAL switch to MANUAL position; a spot should appear on the 'scope screen.
14. Turn the MANUAL SWEEP control through its entire range; if the spot does not follow the same excursion as the sweep observed in step 10, adjust the MAN SW RANGE control on the rear of the main chassis for proper excursion.

NOTE: Large changes of input impedance at the horizontal input of the oscilloscope will affect this adjustment.

MAINTENANCE

GENERAL

1. The preceding initial check-out procedure will equally serve as a periodic routine test of equipment performance, preferably every 3 months.
2. Withe the exception of tubes V201, V202 and V204 in the pyramid generator, tube replacements will not require re-alignment of the instrument. If one of the tubes in the pyramid generator is replaced, it is necessary to follow the PYRAMID GENERATOR ALIGNMENT given in section A.
3. Following that, section B, together with section A, constitutes a complete general alignment procedure for the entire instrument. However, the procedure given in section B is complex, requires extensive test instrumention, and should therefore not be undertaken by personnel not equipped to do so and not until the need is definitely established.
4. It is essential that proper impedance match be achieved in all test set-ups.
5. CAUTION! High voltage potentials are present when the equipment is energized and customary precautions must be taken during servicing.
6. If proper servicing cannot be accomplished in the field, return the instrument to the Service Dept. Jerrold Engineering Laboratory, Byberry Rd. and Turnpike, Hatboro, Pa. Carefully pack the instrument and ship it, with freight and insurance prepaid, together with a letter giving the unit's Serial Number and listing the difficulties encountered. Jerrold will promptly service the instrument at cost and return it in working order.
7. Replacement parts lists are given at the end of the maintenance section.

A. PYRAMID GENERATOR ALIGNMENT

1. Test equipment required:
   a. VTVM . . . . Hewlett-Packard Model 410B or equivalent
   b. Laboratory Type Oscilloscope

2. Energize all instruments and allow 30 minutes for warm-up.
3. Connect the positive probe of the VTVM to pin 7, and the negative probe to pin 4 of the 9-pin test socket at the rear apron of the Model 1015 main chassis; check for reading of 200 volts; if necessary adjust 200 V ADJ potentiometer at the rear apron.
4. Connect the positive lead of the vertical input of the oscilloscope to pin 7, the negative lead to pin 4 of the test socket; set oscilloscope for a-c input and vertical sensitivity to 5 mv/cm; adjust RIPPLE BAL potentiometer at the rear apron of Model 1015 for minimum ripple. Disconnect VTVM.
5. Connect the horizontal input of the oscilloscope to SCOPE HORIZ fitting on Model 1015; set the oscilloscope for d-c input and sensitivity of 10 v/cm. Set PYR SWEEP-MANUAL switch on Model 1015 to MANUAL, and MANUAL SWEEP control to max. ccw excursion. The position of the dot on the oscilloscope screen will correspond to ground potential.
6. Set MANUAL SWEEP control to max. cw excursion and adjust MAN SW RANGE potentiometer to obtain a 40-volt excursion of the dot.
7. Set PYR SWEEP - MANUAL control to PYR SWEEP; set SWEEP RATE switch to 6-60; set FINE control to mid-range. Then adjust PYR REF potentiometer on the pyramid generator chassis so that the extreme left of the waveform coincides with ground potential established in step 5. Then adjust PYR AMPL potentiometer on the pyramid generator chassis so that the extreme right of the waveform coincides with the 40-volt potential established in step 6.
8. Connect SCOPE HORIZ fitting on Model 1015 to the vertical input of the oscilloscope with the latter set for internal sweep operation. Then adjust the PYR SYM potentiometer on the pyramid generator chassis for symmetrical pyramid display.
9. Repeat step 7 to determine if readjustment of PYR REF and PYR AMPL potentiometers is necessary; if so, repeat also step 8. It may be necessary to repeat steps 7 and 8 several times.
10. Disconnect the oscilloscope and connect the positive probe of the VTVM to pin 1 and the negative probe to pin 5 of the test socket at the rear apron of Model 1015; if necessary, adjust the 80 V ADJ potentiometer on the pyramid generator chassis for a reading of 80 volts. Be sure that SWEEP WIDTH and CENTER FREQ. controls are set at 0.

This completes the pyramid generator alignment.

B. GENERAL ALIGNMENT PROCEDURE

a. First complete the pyramid generator alignment given in section A.
b. For section B the following additional test instruments are required:
   1. R-F Sweep Frequency Generator, Jerrold Model 890, 900A, 900B, or equivalent.
   2. Marker Generator, RCA Model WR-99A, or equivalent. (used as frequency calibrator)
   3. Frequency Calibrator, General Radio Model 1213C, or equivalent.
   4. Logarithmic Amplifier, Jerrold Model LA-5100, or equivalent.
   5. Variable Attenuator, Jerrold Model AV-50 (50 ohms) or Model AV-75 (75 ohms), or equivalent.
   6. Coaxial Switch, Jerrold Model FD-30, TC-3, or equivalent.
   7. Dual Linear Broadband Amplifier, Jerrold Model SCA-213-ER-5B or equivalent.
   8. Test Filter, Jerrold Model TF-215.*
   9. R-F Bridge, Jerrold Model KSBV-5N or KSBV-7N, or equivalent.
   10. Tap-Off Unit, Jerrold Model TO-20, or equivalent.
   11. Video Detector, Jerrold Model D-12-B, or equivalent.
   12. Misc. Attenuator Pads.

ALIGNMENT OF MARKER OSCILLATOR

1. Remove the four screws holding the cover on marker oscillator coil assembly; remove the cover.
2. Turn logging control fully to right-hand stop.
3. Loosen all set screws on the solid coupler connecting the oscillator tuning capacitor to the logging dial assembly.
4. Rotate capacitor until plates are fully meshed; then hold a straight-edge against the plates and tighten the set screws on the coupler. Apply Locktite to the screw threads before tightening.
5. Remove coaxial cable connection from J1 on the FUNCTION SWITCH.
6. Set up equipment as shown in fig. 12; energize the equipment and allow 30 minutes warm-up.
7. Set frequency calibrator at 55 mc; set marker generator at 0 (10 on inset dial on Model 1015). Then adjust the 55 MC MARKER trimmer on the oscillator coil assembly to obtain a zero beat at the calibrator.
8. Set frequency calibrator at 40 mc; set marker generator at 15 mc (490 on inset dial of Model 1015). Then adjust the 40 MC MARKER coil on the oscillator coil assembly to obtain a zero beat at the calibrator.
9. Since the two frequency adjustments in steps 7 and 8 interact, it will be necessary to repeat the adjustments until both 55 mc and 40 mc calibration is obtained.
10. Substitute a General Radio Model GR-1213C calibrator in the same set-up (fig. 12) for making fine adjustments for zero beats closest to those found in steps 7-9. As the GR-1213C generates markers at 100 kc intervals, tuning must be made with care, otherwise an adjustment may be off by 100 kc.

* See appendix for construction details.

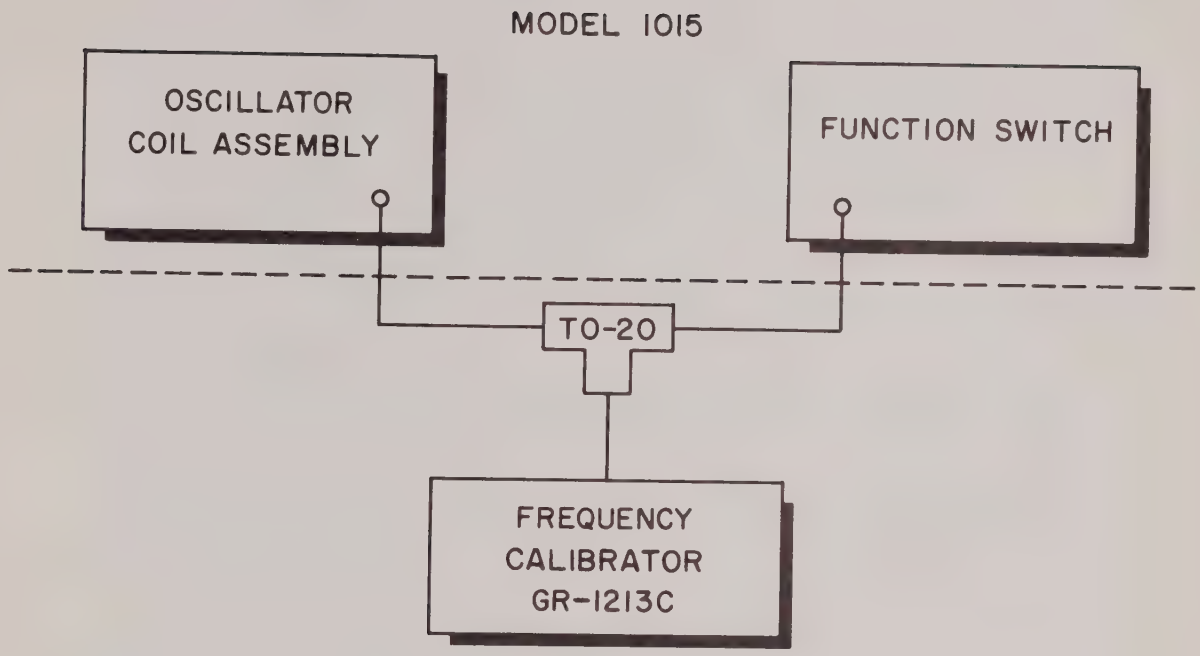


FIG. 12 TEST SET-UP FOR ALIGNMENT OF MARKER OSCILLATOR

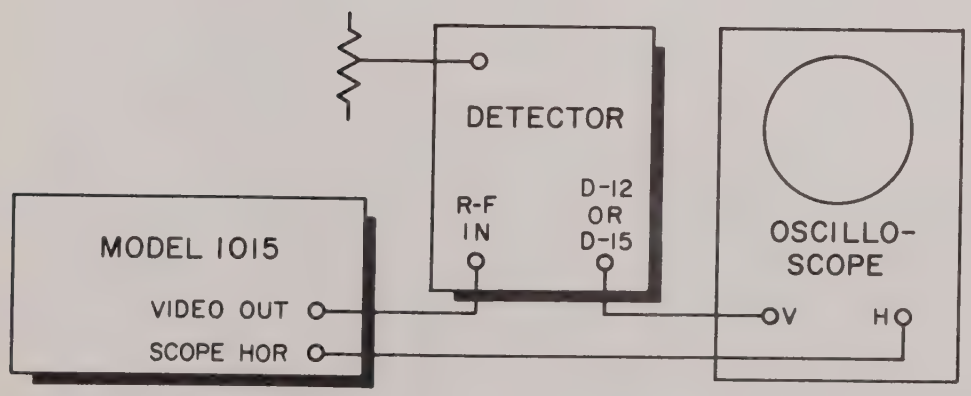


FIG. 13 TEST SET-UP FOR TILT ADJUSTMENT OF WIDE SWEEP

ALIGNMENT OF NARROW SWEEP OSCILLATOR

1. Set up equipment as shown in fig. 11; allow 30 minutes for warm-up.
2. Set SWEEP FUNCTION switch on Model 1015 to CW; tune logging control on Model 1015 to indicate 10 on the inset dial; set oscilloscope horizontal and vertical sensitivity to obtain full scale deflection.
3. Tune the NS 55 MC trimmer on the oscillator coil assembly to obtain zero beat display on the oscilloscope.
4. Pull ALC switch on Model 1015 to OFF position.
5. Adjust OUTPUT LEVEL control on Model 1015 for a reading of -2.5 volts (referenced to ground) at feed-thru capacitor C323 on the narrow sweep oscillator assembly.
6. Set logging control to move zero beat off the display; adjust trimmer C324 on the narrow sweep oscillator assembly to about three turns from maximum capacity.
7. Simultaneously tune coil L308 on the narrow sweep oscillator, and coil L420 on the video mixer, to obtain maximum output indication on the output meter on Model 1015.

ALIGNMENT OF WIDE SWEEP OSCILLATOR

1. With the same set-up as in Fig. 11 set the SWEEP FUNCTION switch on Model 1015 to WIDE; set WIDE SWEEP CENTER FREQ and SWEEP WIDTH controls to zero; set SWEEP RATE switch to 6-60; tune SWEEP RATE FINE control to mid-range; set marker generator slightly off 0 mc.
2. Adjust WS 55 MC trimmer on wide sweep oscillator assembly for zero beat display on the oscilloscope.
3. Tune SWEEP WIDTH control on Model 1015 to 1000; set MARKER GAIN control to mid-range; tune internal marker generator to 15 mc (490 on Model 1015 inset dial).
4. Tune the WIDE SWEEP CENTER FREQ control on Model 1015 so that the zero beat appears at the extreme left of the oscilloscope display.
5. Adjust the WS RANGE potentiometer on the pyramid generator chassis so that the high-frequency (right) end of the sweep coincides with the marker.
6. Turn SWEEP WIDTH control on Model 1015 to 0 (zero); turn WIDE SWEEP CENTER FREQ control to 1000; ALC switch should be ON (pushed in).
7. Adjust CF RANGE potentiometer on the pyramid generator chassis until marker is centered on oscilloscope display.
8. Repeat steps 3 to 7.
9. Set up equipment as shown in fig. 13 for adjustment of wide-sweep tilt (flatness).
10. Set SWEEP WIDTH control to 1000; pull ALC switch to OFF position.
11. Adjust TILT trimmer C430 on the video mixer chassis for flat response on the oscilloscope.

NARROW SWEEP BALANCE ADJUSTMENT

1. Using the same set-up as in fig. 11, set SWEEP FUNCTION switch to NARROW; set SWEEP WIDTH control at 0, and Logging Control to obtain zero beat at mid-trace.
2. Using the oscilloscope controls, center the trace on the oscilloscope.
3. Slowly rotate SWEEP WIDTH control from 0 to 1000 and adjust NS BAL potentiometer on the pyramid generator chassis so that the position of the zero beat is held fixed while the sweep width is varied.

OUTPUT LEVEL ADJUSTMENT AND METER CALIBRATION

1. Disengage SWEEP FUNCTION switch by setting it mid-way between NARROW and WIDE, or between WIDE and CW positions.
2. Check the output level meter on Model 1015 for mechanical zero indication.
3. Connect the positive probe of a high frequency VTVM or power meter to the VIDEO OUTPUT terminal and the common to chassis on Model 1015.

   NOTE: Use a 50-ohm or 75-ohm head with the HP-410, depending on the output impedance of Model 1015 under test.

4. Set the SWEEP FUNCTION switch on Model 1015 to CW and tune marker frequency to 5 mc; switch ALC to ON (pushed in).
5. Adjust OUTPUT LEVEL control on Model 1015 for a reading of +20 dbm on the VTVM; (i.e. 2.236v for 50-ohm versions of Model 1015, and 2.739v for 75-ohm versions).
6. Adjust METER CAL potentiometer at the video mixer chassis for a +20 dbm reading on the output level meter.

NARROW SWEEP BUFFER DRIVE

If maintenance requires replacement of parts in the narrow sweep buffer stage, carry out procedure as under "alignment of narrow sweep oscillator."

VIDEO MIXER ALIGNMENT

1. De-energize Model 1015, then disconnect all leads to the video mixer assembly, except those supplying power; remove the assembly from the Model 1015 and take bottom plate off the video mixer chassis.
2. Loosen the locking nuts on the MIXER DRIVE, MIXER BAL and MIXER BIAS controls.
3. Energize Model 1015; allow for warm-up.
4. Connect the VTVM between pin 8 (screen grid) of tube V401 and ground; if necessary, adjust the MIXER DRIVE control to obtain a reading of +50 volts. Then tighten the locknut on the control.
5. Connect the VTVM between pin 2 (control grid) of tube V402 and ground to obtain a reading of −33 volts; repeat measurement between pin 2 of V403 and ground for the same reading; if necessary, adjust the MIXER BAL and MIXER BIAS controls.
6. Connect a shorting plug to J404 on Model 1015; then set up equipment as shown in fig. 14.
7. Check for input match at J401.
8. Set coaxial switches to automatic switching; set test sweep generator to sweep width of 40 mc about a center frequency of 47.5 mc.
9. Adjust slugs in coils L401, L402 and L403 for a response as shown in fig. 15.
10. Relocate shorting plug from J404 to J405 and arrange test set-up as shown in fig. 16.
11. Set coaxial switcher and sweep generator as in step 8 above; then adjust coils L404 thru L407 for the response shown in fig. 17.
12. Remove shorting plug from J405 and set up equipment as shown in fig. 18; then adjust coil L410 for the response shown in fig. 19.
13. Set up equipment as shown in fig. 20; to do this, disconnect C406 and then connect the free lead of the capacitor to a BNC connector. Also connect a 0.25 uf metallized capacitor from pin 1 (cathode) on tube V402 to ground.
14. Set coaxial switcher for automatic switching; set sweep generator for sweep width of 40 mc about a center frequency of 47.5 mc.
15. Adjust C415, L408, L409, and L412 for the response shown in fig. 21; the response should be flat ± 0.5 db over the 17 mc width from 39 mc to 56 mc. Begin adjustments with C415 set for near minimum capacitance. L408 is effective in the center of the band, while L409 affects the upper edge and L412 and C415 are effective on both sides of the center.
16. De-energize the equipment. Then remove the 0.25 uf test capacitor and reconnect C406 in the video mixer assembly; remount the bottom plate on the video mixer and return the latter to the Model 1015 chassis. Reconnect all leads.

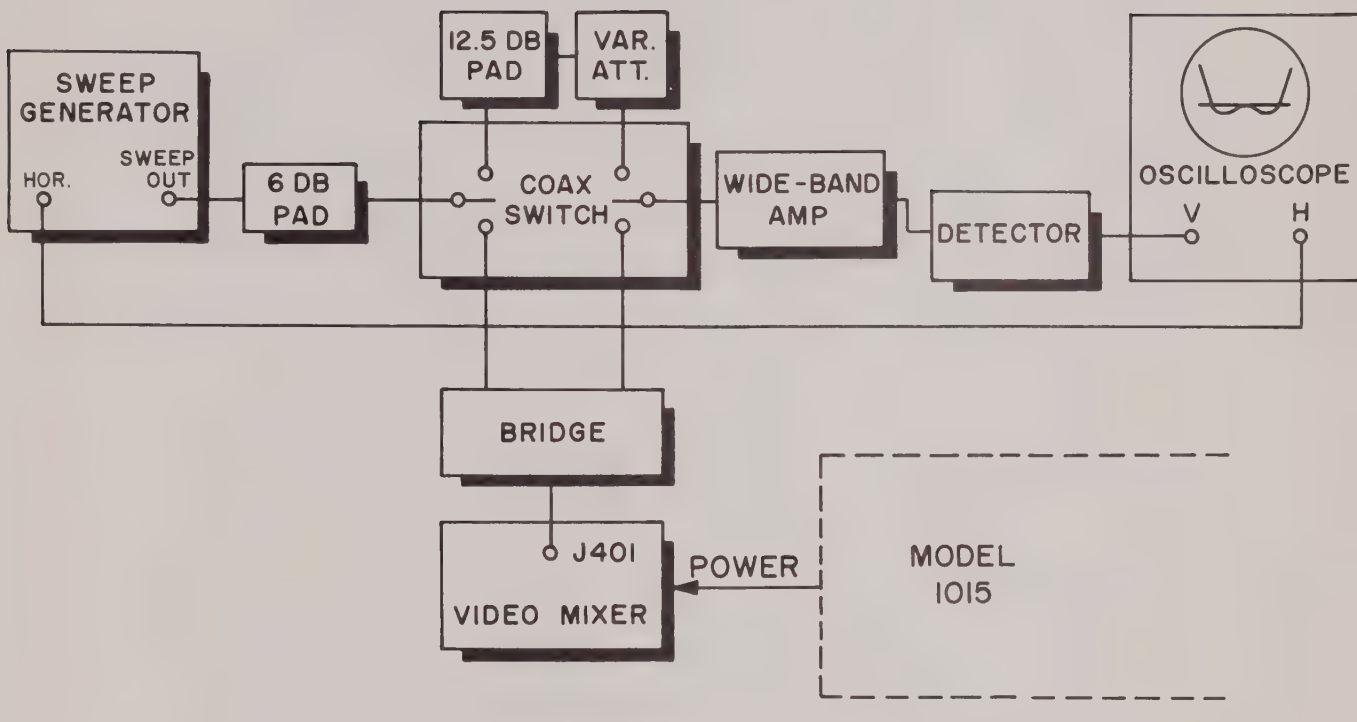


FIG. 14 TEST SET-UP FOR ALIGNMENT OF VIDEO MIXER INPUT

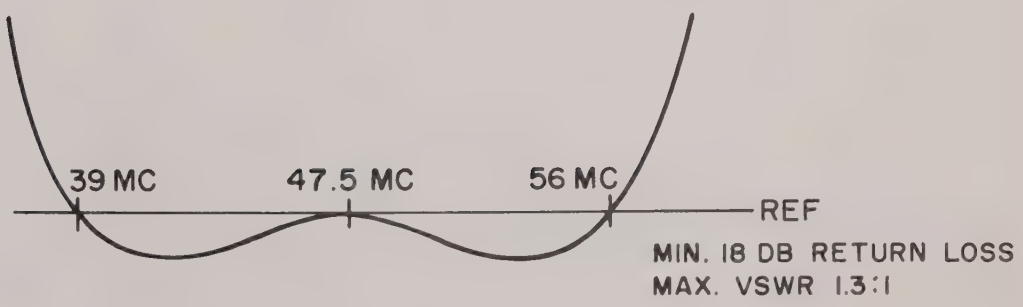


FIG. 15 RESPONSE FOR VIDEO MIXER INPUT STAGE

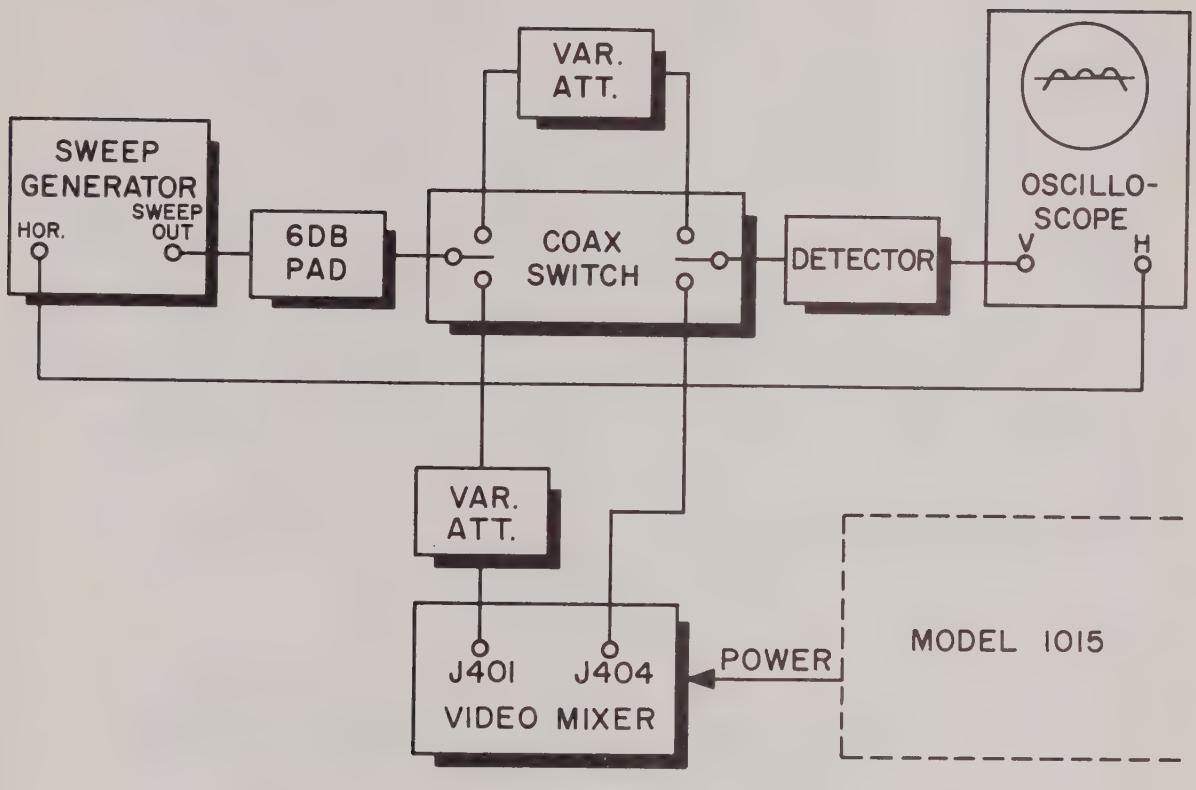


FIG. 16 TEST SET-UP FOR ADJUSTMENT OF VIDEO MIXER GAIN

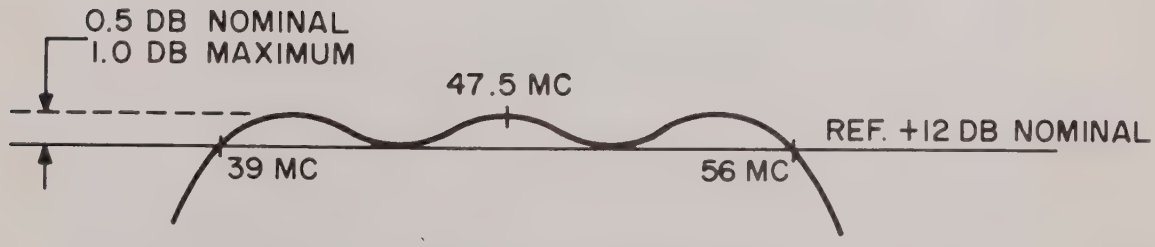


FIG. 17 RESPONSE CURVE OF VIDEO MIXER GAIN

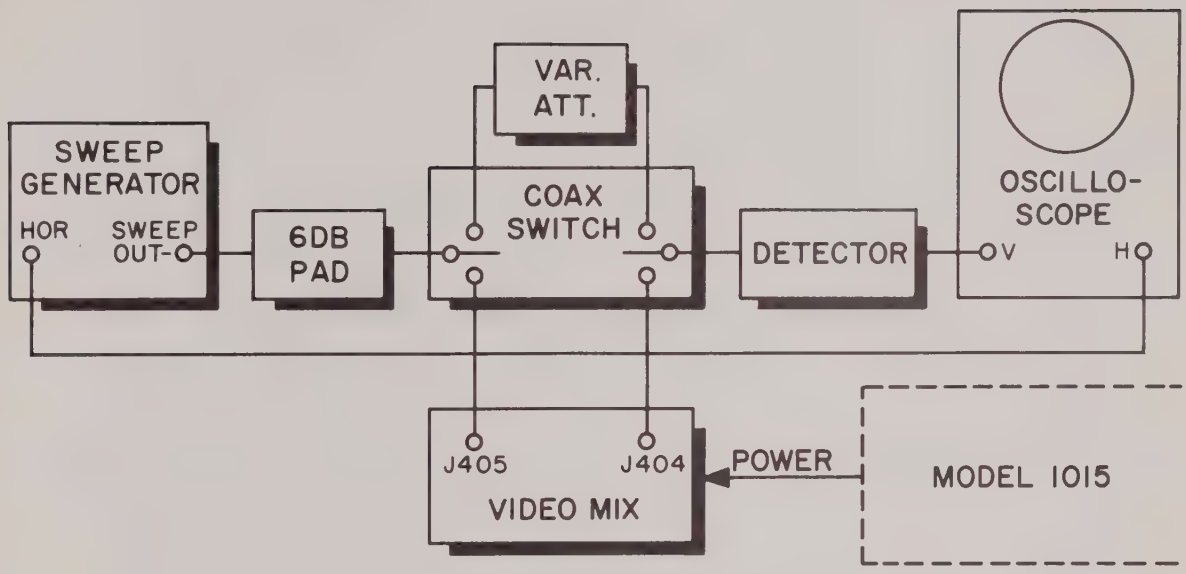


FIG. 18 TEST SET-UP FOR MINIMUM LOSS ADJUSTMENT ON VIDEO MIXER

FIG. 19 RESPONSE CURVE-ADJUSTMENT OF L410

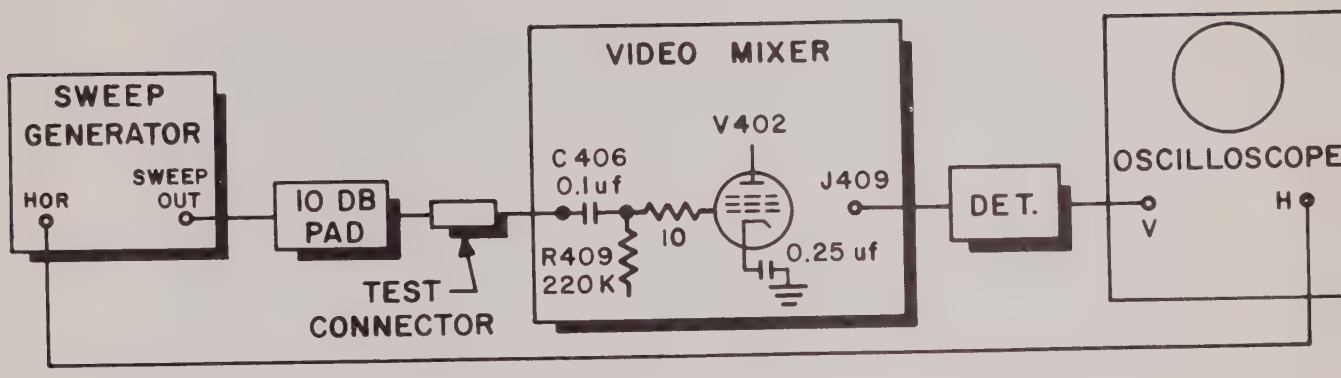


FIG. 20 TEST SET-UP FOR ALIGNMENT OF VIDEO AMPLIFIER

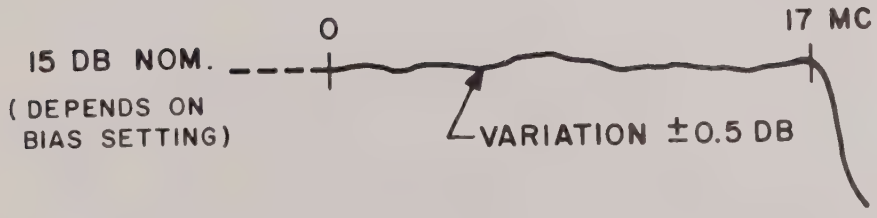


FIG. 21 RESPONSE CURVE — VIDEO AMPLIFIER OUTPUT

VIDEO MIXER - HARMONIC DISTORTION ADJUSTMENT; 55 MC AND 43 MC TRAP ADJUSTMENT.

1. Set up equipment as shown in fig. 22.
2. Set Log Amplifier Model LA-5100 to 80 db range; set AV-50 to 0 (zero).
3. Set the SWEEP FUNCTION switch on Model 1015 to WIDE; set SWEEP WIDTH control to 1000; set WIDE SWEEP CENTER FREQ. control to 0 (zero); turn SWEEP RATE switch to 6-60 and SWEEP RATE FINE control to approx. 30 sweeps per second.
4. Loosen the locking nuts on the MIXER BAL, MIXER BIAS, and MIXER DRIVE controls located on the video mixer chassis; adjust these controls so that the harmonic distortion peaks are at least 46 db down as shown on the response curve in fig. 23.
5. Remove the Model TF-215 test filter from the set-up.
6. Disconnect the cablesfrom J402 and J405 on Model 1015.
7. Set SWEEP FUNCTION switch to CW and set pointer on tuning dial of Model 1015 to 2 mc and adjust L419 for minimum response.
8. Set pointer on tuning dial of Model 1015 to 12 mc and adjust L420 for minimum response.
9. Rotate logging control slowly through its entire range and, if necessary, readjust L419 and L420 so that the traps are equally effective over the entire range.
10. Reconnect cables to J402 and J405 on Model 1015.

This completes the alignment procedure.

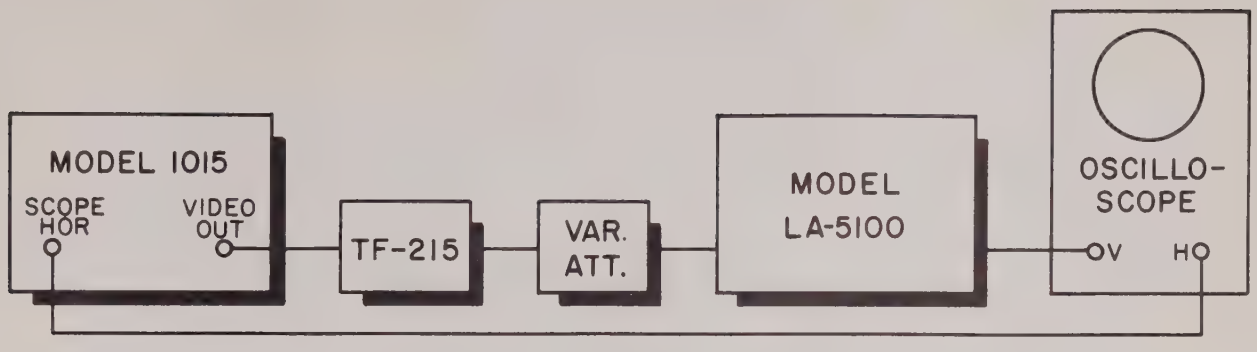
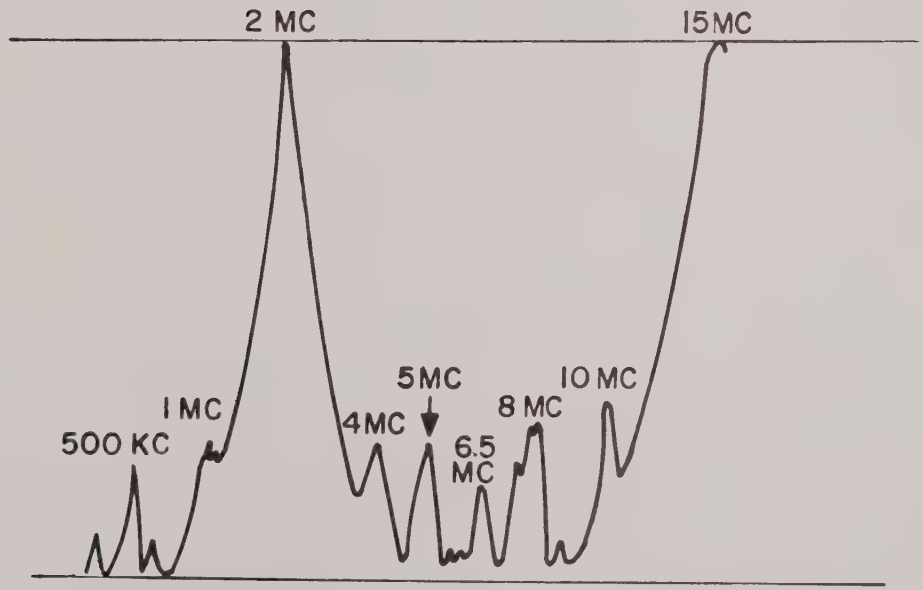


FIG. 22 TEST SET-UP-ADJUSTMENT OF VIDEO MIXER FOR MINIMUM HARMONIC DISTORTION



1 MC..... -58 DB
4 MC..... -56 DB
5 MC..... -56 DB
8-10 MC..... -48 DB

FIG. 23 RESPONSE CURVE – VIDEO MIXER ADJUSTED FOR MINIMUM HARMONIC DISTORTION.

REPLACEMENT PARTS LIST VIDEO SWEEP GENERATOR MODEL 1015

ASSEMBLY MARKER MIXER AND AMPLIFIER REF. DWG. NO.: 861-447

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C501	1	50 pf, 10%, 600v, tubular ceramic	123-122
2	C502	1	22 pf, 2%, 600v, temp. coef.	121-015
3	C503,504,510, 516	4	0.02 uf, disc	124-034
4	C505,515	2	100 pf, cer.	123-105
5	C506,514,517-524	10	1000 pf, feed-thru	129-200
6	C507,513	2	47 pf, 10%, feed-thru	129-202
7	C508,509	2	2000 pf, 10%, 1000v, disc	124-050
8	C511	1	0.01 uf, 200v, molded paper	125-048
9	C512	1	1000 pf	123-115
			CONNECTORS	
10	J501-504	4	Receptacle, BNC, UG 657/U	188-103
			ELECTRON TUBES	
11	V501	1	6AU6	131-308
12	V502,503	2	6AN8	131-352
			RECTIFIER	
13	CR501	1	1N34	139-100
			RESISTORS	
14	R501,507	2	51 ohm, 5%, ½w	112-200
15	R502	1	10 ohm, 5%, ½w	112-107
16	R503,505	2	10K, 5%, ½w	112-485
17	R504	1	150 ohm, 5%, ½w	112-254
18	R506,510	2	47K, 5%, ½w	112-569
19	R508,521	2	220K, 5%, ½w	112-653
20	R509,513, 516,518	4	100K, 5%, ½w	112-611
21	R511,519	2	1K, 5%, ½w	112-359
22	R512,520	2	1 meg., 5%, ½w	112-737
23	R514	1	2.2K, 5%, ½w	112-401
24	R515	1	100 ohm, 5%, ½w	112-233
25	R517	1	820 ohm, 5%, ½w	112-350
26	R522	1	300K, 5%, ½w	112-671
27	R523	1	2 meg., 5%, ½w	112-776
28	R524	1	8.2 meg., 5%, ½w	112-854

REPLACEMENT PARTS LIST — VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY MARKER OSCILLATOR — REF. DWG. NO.: 861-448

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C310,313	2	510 pf, 500v, silver mica	126-051
2	C311	1	1000 pf, stand-off	129-199
3	C312,316,317	3	1000 pf, feed-thru	129-200
4	C314,315	2	1000 pf, 600v	123-115
			CONNECTORS	
5	P301,303	2	Plug, BNC, UG 88/U	183-204
			ELECTRON TUBE	
6	V302	1	6922	131-602
			RESISTORS	
7	R310,313,314, 315	4	10 ohm, 5%, ½w	112-107
8	R311,312	2	10K, 10%, 2w	112-490
9	R316	1	22K, 5%, ½w	112-527

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY WIDE SWEEP OSCILLATOR REF. DWG. NO.: 861-449

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C301,304,308 309	4	1000 pf, feed-thru	129-200
2	C302,305	2	510 pf, 500v, silver mica	126-051
3	C303	1	1000 pf, stand-off	129-199
4	C306,307	2	1000 pf, 600v	123-115
			CONNECTORS	
5	P304,305	2	Plug, BNC, UG 88/U	183-204
			ELECTRON TUBE	
6	V301	1	6922	131-602
			RESISTORS	
7	R301,306	2	4.7K, 5%, $\frac{1}{2}$w	112-443
8	R302,303,307, 308	4	10 ohm, 5%, $\frac{1}{2}$w	112-107
9	R304,305	2	10K, 10%, 2w	112-490

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY OSCILLATOR COILS — REF. DWG. NO.: 861-452

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C337,343	2	1000 pf, feed-thru	129-108
2	C338	1	10 pf, ± 0.1 pf, 500v	121-077
3	C339	1	7.5 pf, ± 0.25 pf, 600v	121-041
4	C340,346,354	3	0.7-10 pf, trimmer	821-141
5	C341,342,347, 348,355,356	6	68 pf, 2%, 500v, silver mica	126-062
6	C344	1	82 pf, 2%, 600v, temp. coef.	121-031
7	C345	1	5.6 pf, ± 0.5 pf, 600v	121-112
8	C349	1	8-50 pf, trimmer, ceramic	128-501
9	C350	1	43 pf, 2%, 600v, temp. coef.	121-023
10	C351	1	Variable, 4 rotor and stator plates	128-211
11	C353	1	4.7 pf, ± 0.5 pf, 600v	121-206
12	C357	1	39 pf, 2%, 600v, temp. coef.	121-022
13	C358	1	15 pf, 2%, 600v	121-204
14	C359	1	3.3 pf, ± 0.25 pf, 600v, temp. coef.	121-006
15	C360,361,362	3	Varicap, HC-7001 (Hughes)	128-212
			CONNECTORS	
16	J301-308	8	Receptacle, BNC, UG 657/U	118-103
			RESISTORS	
17	R331,338	2	560 ohm, 5%, ½w	112-329
18	R332,333,336, 337	4	3 ohm, 5%, ½w	112-005
19	R334	1	4.7K, 5%, ½w	112-443
20	R335	1	620 ohm, 5%, ½w	112-335
21	R339,340	2	10 ohm, 5%, ½w	112-107
22	R341	1	50 ohm, 1%, ½w	115-141

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY NARROW SWEEP OSCILLATOR REF. DWG. NO.: 861-454

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C318,319	2	510 pf, 500v, silver mica	126-051
2	C320	1	1000 pf, stand-off	129-199
3	C321,322,323, 324,330,332, 334	7	1000 pf, feed-thru	129-200
4	C324	1	0.7 - 3 pf, 350v, trimmer	128-515
5	C325,326,328	3	0.01 uf, 600v	124-031
6	C327	1	56 pf, silver mica	126-064
7	C331,333,335, 336	4	1000 pf, 600v	123-115
			CONNECTORS	
8	J310	1	Receptacle, BNC, UG 657/U	188-103
9	P307,308	2	Plug, BNC, UG 88/U	183-204
			ELECTRON TUBES	
10	V303	1	6922	131-602
11	V304	1	6EJ7	131-340
			RESISTORS	
12	R317,324	2	4.7K, 5%, $\frac{1}{2}$w	112-443
13	R318,319,322, 325,326	5	10 ohm, 5%, $\frac{1}{2}$w	112-107
14	R320,321	2	10K, 10%, 2w	112-490
15	R323	1	22K, 5%, $\frac{1}{2}$w	112-527
16	R327	1	47K, 5%, $\frac{1}{2}$w	112-569
17	R328	1	180 ohm, 5%, $\frac{1}{2}$w	112-266
18	R329,330	2	1K, 5%, $\frac{1}{2}$w	112-359

REPLACEMENT PARTS LIST VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY VIDEO MIXER AND AMPLIFIER; Ser. A, B, C **REF. DWG. NO.:** 861-457

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C401	1	36 pf, 2%, 600v, temp. coef.	121-021
2	C402	1	100 pf, 2%, 600v, temp. coef.	121-033
3	C403	1	0.51 pf, 10%, gimmick	122-037
4	C404,408,409, 412,417,420, 435-438,442, 444,445,446	14	0.01uf, 600v, disc	124-031
5	C405	1	13 pf, ± 0.25 pf, 600v, temp. coef.	121-043
6	C406,407	2	0.1 uf, 50v, disc	124-059
7	C410,413	2	1.5 pf, ± 0.25 pf, 600v, temp. coef.	121-049
8	C411	1	5.6 pf, ± 0.25 pf, 600v, temp. coef.	121-044
9	C414,416	2	4 uf, 250v, electrolytic	127-043
10	C415	1	0.7-3pf, 350v, trimmer	128-515
11	C418,422,439	3	1000 pf, 600v, disc	123-115
12	C419,423	2	0.25 uf, 200v, metalized paper	125-008
13	C421,424,425	3	0.1 uf, 200v, metalized paper	125-002
14	C426,470	2	11 pf, 2%, 600v, temp. coef.	121-067
15	C427	1	3-12 pf, trimmer, ceramic	128-520
16	C428	1	47 pf, 2%, 600v, temp. coef.	121-024
17	C429	1	12 uf, 250v, electrolytic	127-001
18	C430	1	0.7-10 pf, trimmer	821-203
19	C431,432,434	3	5000 pf, 600v, disc	124-029
20	C433	1	0.5 uf, 200v, metalized paper	125-050
21	C440	1	1000 pf, feed-thru	129-200
22	C441	1	1.8 pf, feed-thru, Teflon	129-226
23	C443	1	12 uf, 150v, electrolytic	127-016
24	C447	1	5.1 pf, ± 0.25 pf, 600v, temp. coef.	121-051
			CONNECTORS	
25	J401,402,404-409	8	Receptacle, BNC, UG 567/U	188-103
26	P101	1	Plug	184-038
			ELECTRON TUBES	
27	V401	1	6EJ7	131-340
28	V402,403	2	12BY7A	131-403
29	V404	1	6922	131-602
30	V405,406	2	6CW5	131-337
31	V407	1	6U8	131-320
			RECTIFIERS	
32	CR401	1	1N34	139-100
33	CR402,403	2	K34	139-102
34	CR404	1	1N456	139-166

REPLACEMENT PARTS LIST

ASSEMBLY — REF. DWG. NO.: 861-457

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			RESISTORS	
35	R401	1	470 ohm, 5%, ½w	112-317
36	R402,449	2	10K, 5%, ½w	112-485
37	R403	1	4.7K, 10%, ½w	112-447
38	R404	1	10K, 10%, 2w, potentiometer	118-206
39	R405	1	15K, 10%, 2w	112-511
40	R406	1	6.8K, 10%, 1w	112-469
41	R407,408	2	510 ohm, 5%, ½w	112-326
42	R409,415, 443	3	220K, 5%, ½w	112-653
43	R410,414, 434	3	270K, 5%, ½w	112-665
44	R411,413	2	36K, 5%, ½w	112-557
45	R412	1	50K, 2w, potentiometer	118-024
46	R416	1	500K, 2w, potentiometer	118-030
47	R417,418, 428,432, 441,442	6	10 ohm, 5%, ½w	112-107
48	R419	1	51 ohm, 5%, ½w	112-200
49	R420	1	3.6K, 5%, ½w	112-431
50	R421,422	2	30K, 5%, ½w	112-545
51	R423,424, 431,466,467	5	1K, 5%, ½w	112-359
52	R425	1	2K, 5%, 1w	112-399
53	R426	1	100 ohm, 5%, ½w	112-233
54	R427,429	2	560K, 5%, ½w	112-707
55	R430	1	330 ohm, 5%, ½w	112-296
56	R433	1	120 ohm, 5%, ½w	112-245
57	R435	1	150K, 5%, ½w	112-632
58	R437,438	2	220 ohm, 10%, 1w	112-280
59	R439	1	180K, 5%, ½w	112-644
60	R440	1	200 ohm, 5%, ½w	112-272
61	R444	1	5.1K, 5%, ½w	112-452
62	R445	1	150 ohm, 10%, 2w	112-259
63	R446	1	6.8K, 10%, 1w	112-468
64	R447	1	560 ohm, 5%, ½w	112-329
65	R448,453,464	3	100K, 5%, ½w	112-611
66	R450 (50 ohm model)	1	50 ohm, 1%, ½w	115-148
	R450 (75 ohm model)	1	75 ohm, 1%, ½w	115-108
67	R451	1	1.5K, 5%, ½w	112-380
68	R452	1	680 ohm, 5%, ½w	112-338
69	R459	1	2K, 5%, ½w	112-398
70	R457	1	500 ohm, 2w, potentiometer	118-053
71	R458	1	240 ohm, 5%, ½w	112-284

REPLACEMENT PARTS LIST

ASSEMBLY REF. DWG. NO.: 861-457

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
72	R460,463	2	200K, 5%, ½w	112-650
73	R461	1	1.8K, 5%, ½w	112-392
74	R462	1	2.2K, 5%, ½w	112-401
75	R465	1	51K, 5%, ½w	112-578
76	R468	1	4.7 meg., 10%, ½w	112-824
77	R472	1	11K, 5%, ½w	112-494
78	R473	1	1K, 10%, 2w	112-364
			TRANSFORMER	
79	T401	1	Iron torroid	144-070

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY FRONT PANEL REF. DWG. NO.: 861-543

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C1	1	10 uf, 150v	125-047
2	C2	1	1 uf, 200v	125-019
3	C3,6	2	0.1 uf, 200v	125-002
4	C4	1	0.01 uf, 400v	125-013
5	C5	1	0.01 uf, 600v	124-031
			CONNECTORS	
6	J1-4	4	Receptacle, BNC, UG 657/U	188-103
			METER	
7	M1	1	Output meter	171-218
			PILOT LIGHTS	
8	DS1,2	2	Lamp	102-513
			RESISTORS	
9	R1	1	5 meg., 2w, potentiometer	118-054
10	R2	1	10K, 10%, 2w, potentiometer	118-044
11	R3,4	2	100K, potentiometer	118-099
12	R5	1	100K, 5%, $\frac{1}{2}$w	112-611
13	R6	1	25K, 2w, potentiometer	118-093
14	R7	1	220K, 5%, $\frac{1}{2}$w	112-653
15	R8/S6	1	500K, potentiometer w/spdt push-pull sw.	118-114
16	R9	1	2.2 meg., 5%, $\frac{1}{2}$w	112-779
17	R10,11	2	56K, 5%, $\frac{1}{2}$w	112-581
			SWITCHES	
18	S1	1	2 pole, 5 position	161-121
19	S2	1	2 pole, 3 position	161-103
20	S3	1	Spst, toggle	162-001
21	S4	1	Coaxial switch assembly	822-050
22	S5	1	Spdt, toggle	162-007

REPLACEMENT PARTS LIST VIDEO SWEEP GENERATOR MODEL 1015

ASSEMBLY REAR PANEL REF. DWG. NO.: 861-553

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C601	1	500 pf, 10%	123-233
2	C602,603,605, 606	4	8.2 pf, 500v	121-010
3	C604,607	2	1000 pf, 600v, disc	123-115
			CONNECTORS	
4	J601-606, 609,610,611	9	Receptacle, BNC, UG 657/U	188-103
5	J607,608	2	Receptacle, BNC, UG 909/U	185-106
			RESISTORS	
6	R601-604 (50 ohm model)	4	50 ohm, 1%, $\frac{1}{2}$w	115-141
	R601-604 (75 ohm model)	4	75 ohm, 1%, $\frac{1}{2}$w	115-108
7	R607	1	100K, 5%, $\frac{1}{2}$w	112-611
8	R608	1	1 meg., 5%, $\frac{1}{2}$w	112-737
			SWITCHES	
9	S601-608	8	Mercury (Clare)	160-100

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY PYRAMID GENERATOR AND SWEEP DRIVER REF. DWG. NO.: 861-554

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CONNECTOR	
1	P103	1	Plug, 25 pin	184-039
2	V201,202,204,		ELECTRON TUBES	
	205	4	12AT7	131-400
3	V203	1	6U8	131-320
			RESISTORS	
4	R201	1	91K, 5%, ½w	112-608
5	R202,207	2	250K, potentiometer	118-100
6	R203,212	2	1 meg., 5%, ½w	112-737
7	R204,208	2	300K, 5%, ½w	112-914
8	R205	1	3.6 meg., 5%, ½w	112-809
9	R206,222,252	3	1K, 5%, ½w	112-359
10	R209,211,250	3	68K, 5%, ½w	112-590
11	R210,214	2	511K, 1%, ½w	115-104
12	R213,215,219	3	150K, 5%, ½w	112-632
13	R216	1	470K, 10%, ½w	112-698
14	R217,236	2	100K, 2w, potentiometer	118-022
15	R218	1	560K, 5%, ½w	112-707
16	R220,228	2	100K, 5%, ½w	112-611
17	R221	1	200K, 5%, ½w	112-650
18	R223	1	510K, 5%, ½w	112-704
19	R224	1	2.7 meg., 5%, ½w	112-791
20	R225	1	10 meg., 10%, ½w	112-866
21	R226	1	500K, 2w, potentiometer	118-030
22	R227	1	620K, 5%, ½w	112-713
23	R229	1	22K, 5%, ½w	112-527
24	R230	1	62K, 5%, ½w	112-587
25	R231	1	25K, 10%, 2w, potentiometer	118-027
26	R232,235,243,			
	244	4	1 meg., 1%, ½w	115-105
27	R233	1	1 meg., 2w, potentiometer	118-050
28	R234	1	4.22 meg., 1%, ½w	115-107
29	R237	1	383K, 1%, ½w	115-103
30	R238,239	2	6.8K, 5%, ½w	112-464
31	R240	1	39K, 5%, ½w	112-560
32	R241	1	2.61 meg., 1%, ½w	115-152
33	R242	1	30K, 5%, ½w	112-545
34	R245,251	2	10K, 5%, ½w	112-485
35	R246	1	470 ohm, 5%, ½w	112-317
36	R247	1	18K, 5%, ½w	112-520
37	R248	1	1.5 meg., 5%, ½w	112-758
38	R249	1	180K, 5%, ½w	112-644
39	R253	1	130K, 5%, ½w	112-629

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY: VIDEO MIXER AND AMP. Ser. D REF. DWG. NO.: E861-762

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			CAPACITORS	
1	C401	1	36 pf, 2%, 600 v, TCZ	121-021
2	C402	1	470 pf, 20%, 600 v	123-113
3	C403	1	0.5 pf, 10%	122-037
4	C404, 406,408 409, 412, 417 420, 435-438 442, 445, 454 455	16	0.01uf, 600 v, disc	124-031
5	C405, 410	2	8-50 pf, trimmer	128-501
6	C407, 444	2	0.02 uf, 25 v	124-065
7	C411	1	5.6 pf, 600 v, TCZ	121-044
8	C413	1	1.5 pf, 600 v, TCZ	121-049
9	C414, 416	2	4 uf, 250 v, electrolytic	127-043
10	C415	1	0.7-3 pf, trimmer	128-515
11	C418, 422, 439	3	1000 pf, 600 v, disc	123-115
12	C419, 423	2	0.25 uf, 200 v	125-008
13	C421, 424, 425	3	0.1 uf, 200 v	125-002
14	C426, 427	2	3-12 pf, trimmer	128-250
15	C428	1	47 pf, 600 v, TCZ	121-024
16	C429	1	12 uf, 250 v, electrolytic	127-001
17	C430	1	0.7-10 pf, trimmer	821-203
18	C431, 432, 434	3	5000 pf, 600 v, disc	124-029
19	C433	1	0.5 uf, 200 v	125-050
20	C440, TP1, TP2	3	1000 pf, feed-thru	129-200
21	C441	1	1.8 pf, feed-thru	129-226
22	C443	1	12 uf, 250 v, electrolytic	127-016
23	C447	1	5.1 pf, 600 v, TCZ	121-051
24	C448, 449	2	68 pf, mica	126-099
25	C450, 451	2	100 pf, mica	126-091
26	C452, 453	2	47 pf, mica	126-102
			CONNECTORS	
27	J401, 402, 404-409	8	"BNC" fittings	188-103
28	P101	1	8-pin plug	184-038
29	P404	1	shorting connector	183-236

REPLACEMENT PARTS LIST

VIDEO SWEEP GENERATOR
MODEL 1015

ASSEMBLY: VIDEO MIXER AND AMP. Ser. D REF. DWG. NO.: E861-762

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			DIODES	
30	CR401	1	1N34	139-100
31	CR402, 403	2	K3A	139-102
32	CR404	1	1N456	139-166
33	CR405-408	4	factory-selected	
			RESISTORS	
34	R401	1	430 ohms, 5%, 1/2 w	112-314
35	R402, 449	2	10 k, 5%, 1/2 w	112-458
36	R403	1	68 ohms, 5%, 1/2 w	112-212
37	R404, 426	2	100 ohms, 5%, 1/2 w	112-233
38	R405	1	3.3 k, 5%, 1/2 w	112-422
39	R406, 409	2	10 k, 5%, 1/4 w	112-004
40	R407, 408	2	5.1 ohms, 1/4 w	112-070
41	R410, 411	2	270 ohms, 5%, 1/2 w	112-287
42	R412, 416, 443	3	220 k, 5%, 1/2 w	112-653
43	R413, 415	2	36 k, 5%, 1/2 w	112-557
44	R414	1	50 k, 2 w, potentiometer	118-024
45	R417, 418, 428 432, 436, 441 442	7	10 ohms, 5%, 1/2 w	112-107
46	R419	1	51 ohms, 5%, 1/2 w	112-200
47	R420, 459	2	3.6 k, 5%, 1/2 w	112-431
48	R421, 422	2	30 k, 5%, 1/2 w	112-545
49	R423, 424, 431 466, 467	5	1 k, 5%, 1/2 w	112-359
50	R425	1	2 k, 5%, 2 w	112-400
51	R427, 429	2	560 k, 5%, 1/2 w	112-707
52	R430	1	330 ohms, 5%, 1/2 w	112-296
53	R433	1	120 ohms, 5%, 1/2 w	112-245
54	R434	1	270 k, 5%, 1/2 w	112-665
55	R435	1	150 k, 5%, 1/2 w	112-632
56	R437, 438	2	220 ohms, 10%, 2 w	112-280
57	R439	1	180 k, 5%, 1/2 w	112-644
58	R440	1	200 ohms, 5%, 1/2 w	112-272
59	R444	1	5.1 k, 5%, 1/2 w	112-452
60	R445	1	150 ohms, 10%, 2 w	112-259

REPLACEMENT PARTS LIST — VIDEO SWEEP GENERATOR MODEL 1015

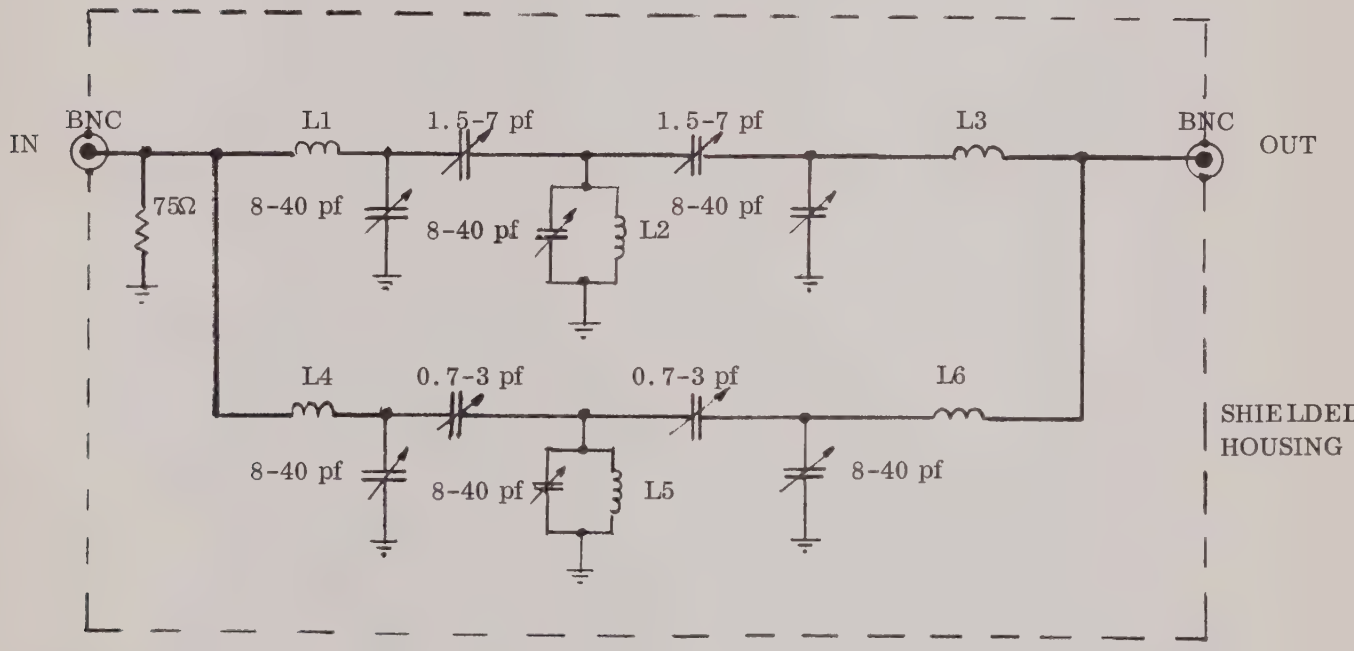
ASSEMBLY: VIDEO MIXER AND AMP., Ser. D — REF. DWG. NO.: E861-762

ITEM	SCHEMATIC DESIGNATION	QTY	DESCRIPTION	JERROLD PART NO.
			RESISTORS, cont.	
61	R446	1	6.8 k, 10%, 1 w	112-468
62	R447	1	560 ohms, 5%, 1/2 w	112-329
63	R448,453,454 455,464	5	100 k, 5%, 1/2 w	112-611
64	R450(50-ohm Model)	1	50 ohms, 1%, 1/2 w	115-149
	(75-ohm Model)	1	75 ohms, 1%, 1/2 w	115-148
65	R451,452	2	1.5 k, 5%, 1/2 w	112-380
66	R456	1	500 k, 2 w, potentiometer	118-030
67	R457	1	500 ohms, 2 w, potentiometer	118-053
68	R458	1	240 ohms, 5%, 1/2 w	112-284
69	R460, 463	2	200 k, 5%, 1/2 w	112-650
70	R461	1	1.8 k, 5%, 1/2 w	112-392
71	R462	1	2.2 k, 5%, 1/2 w	112-401
72	R465	1	51 k, 5%, 1/2 w	112-578
73	R468	1	4.7 meg., 10%, 1/2 w	112-824
74	R469	1	1 k, 5 w, wire-wound	113-061
75	R470	1	1.2 k, 5%, 1/2 w	112-371
76	R471	1	11 k, 5%, 1/2 w	112-494
			TUBES	
77	V401,402,403	3	12BY7A	131-403
78	V404	1	6922	131-602
79	V405, 406	2	6CW5	131-337
80	V407	1	6U8	131-320

APPENDIX

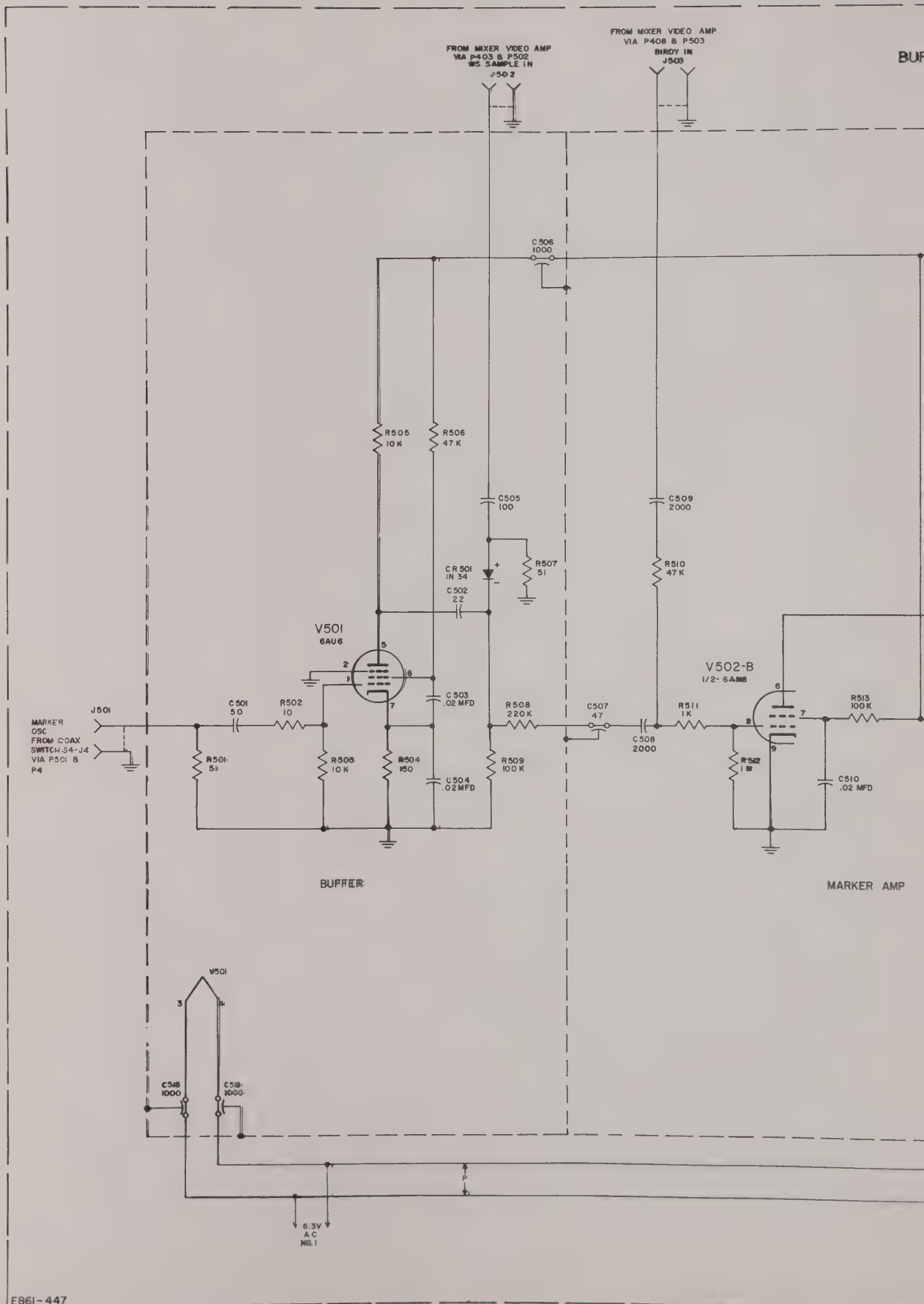
CONSTRUCTION OF BANDPASS FILTER MODEL TF-215

This test filter is for use in alignment of the video mixer stage of Model 1015 for minimum harmonic distortion.

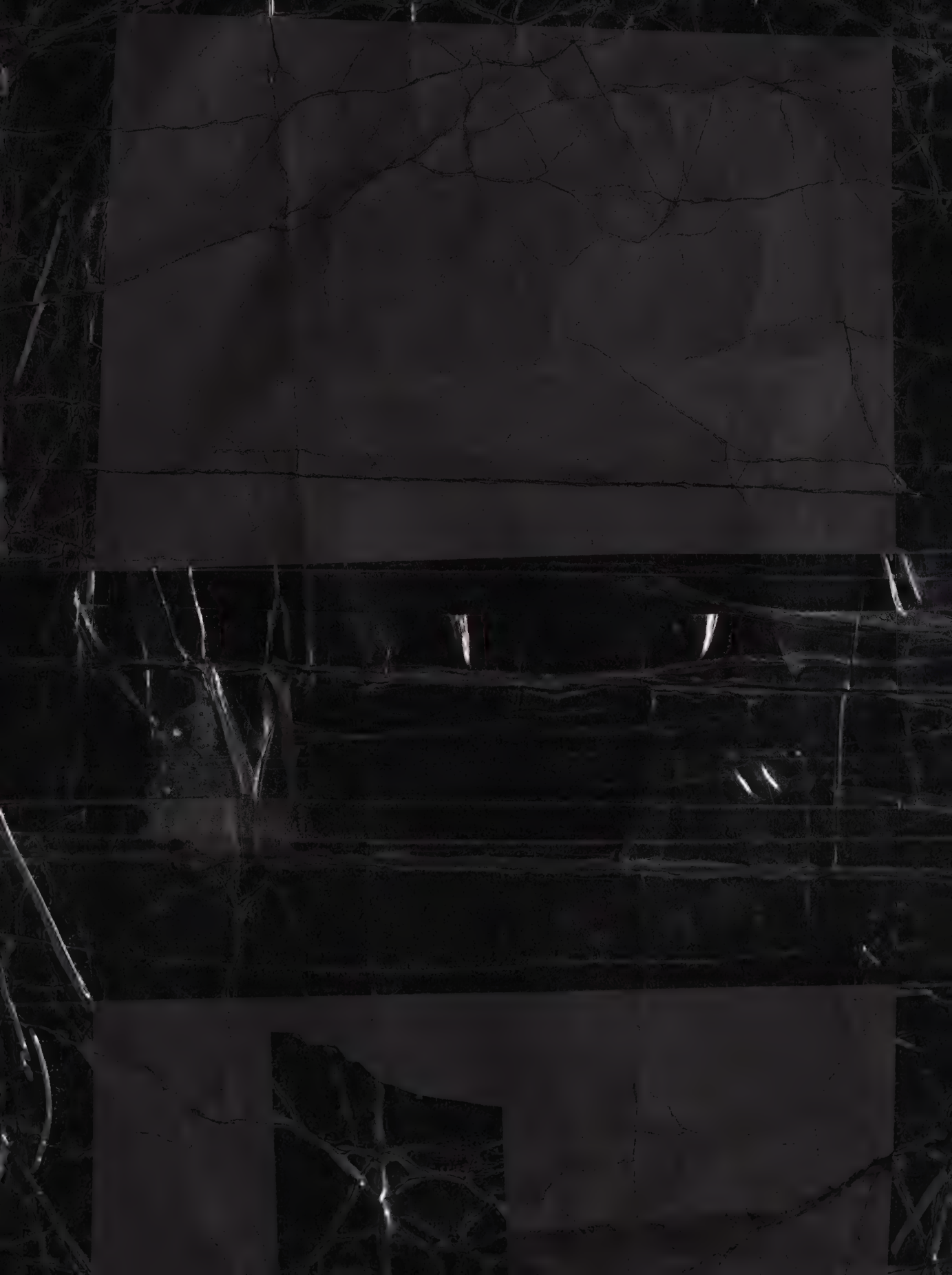


NOTES:

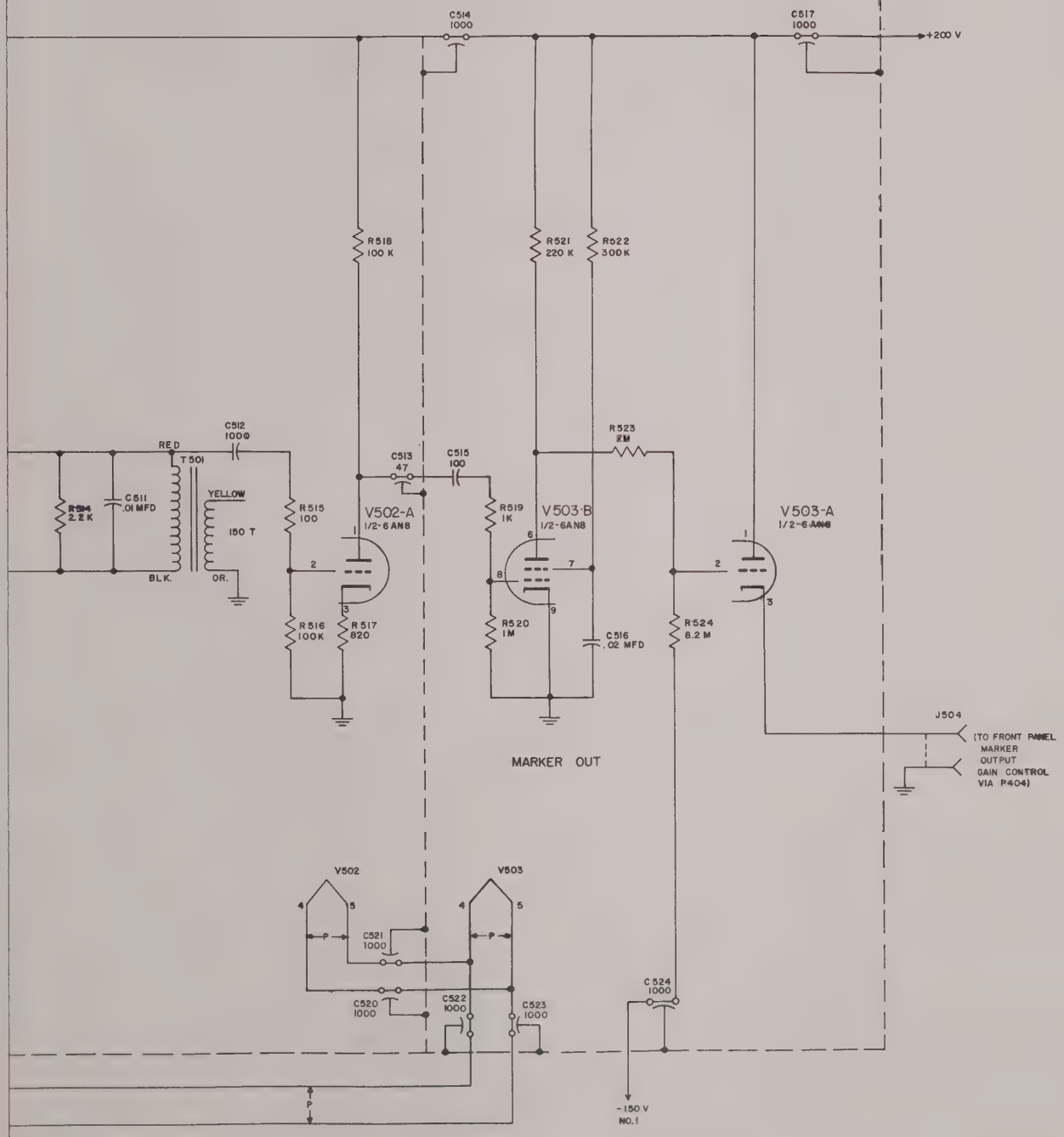
1. All coils use about 95 turns #34 SP wire on 1/4" d. threaded paper forms.
2. L1, L2, L3 use threaded iron cores.
3. L4, L5, L6 use thread brass cores.
4. L1, L2, L3 affect the 2 mc end.
5. L4, L5, L6 affect the 15 mc end.
6. IN and OUT fittings are "BNC" type.
7. The filter circuit must be built into a housing giving complete shielding.


FROM MIXER VIDEO AMP VIA P403 & P502 WS SAMPLE IN J502
FROM MIXER VIDEO AMP VIA P408 & P503 BIRDY IN J503
C506 1000
R505 10K
R506 47K
C505 100
C509 2000
CR501 IN 34
R507 51
R510 47K
C502 22
V501 6AU6
V502-B 1/2-6AN8
J501 MARKER OSC FROM COAX SWITCH J4-J4 VIA P501 & P4
C501 50
R502 10
C503 .02 MFD
R508 220K
C507 47
R511 1K
R513 100K
R501 51
R503 10K
R504 150
C504 .02 MFD
R509 100K
C508 2000
R512 1M
C510 .02 MFD
BUFFER
MARKER AMP
V501
C518 1000
C519 1000
P1
6.3V AC NO. 1

E861-447



SCHEMATIC
FER, MIXER, & MARKER AMP.
MODEL 1015

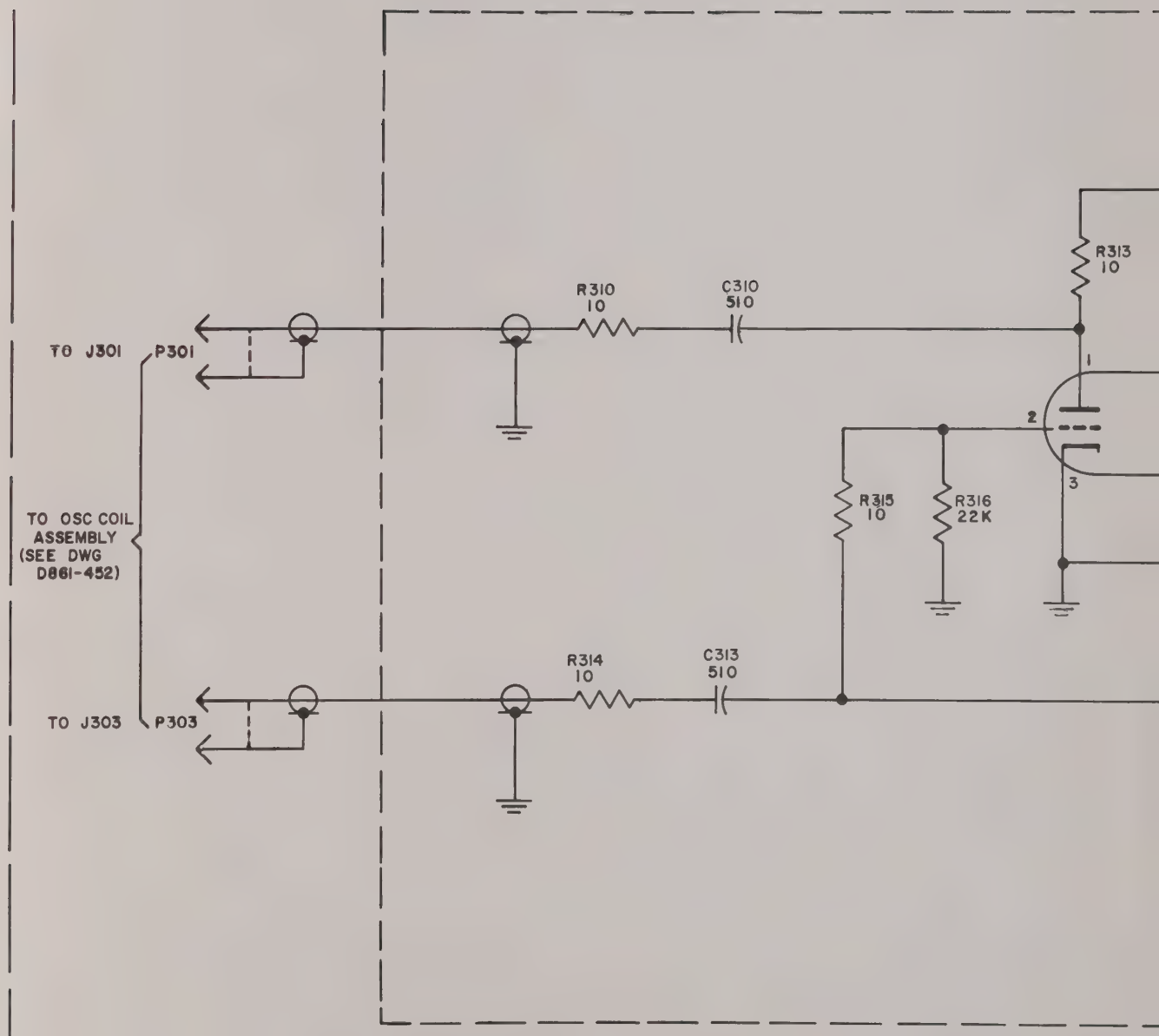


NOTES:
1. ALL RESISTOR VALUES IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITOR VALUES IN PF UNLESS OTHERWISE SPECIFIED

SCHEMAT

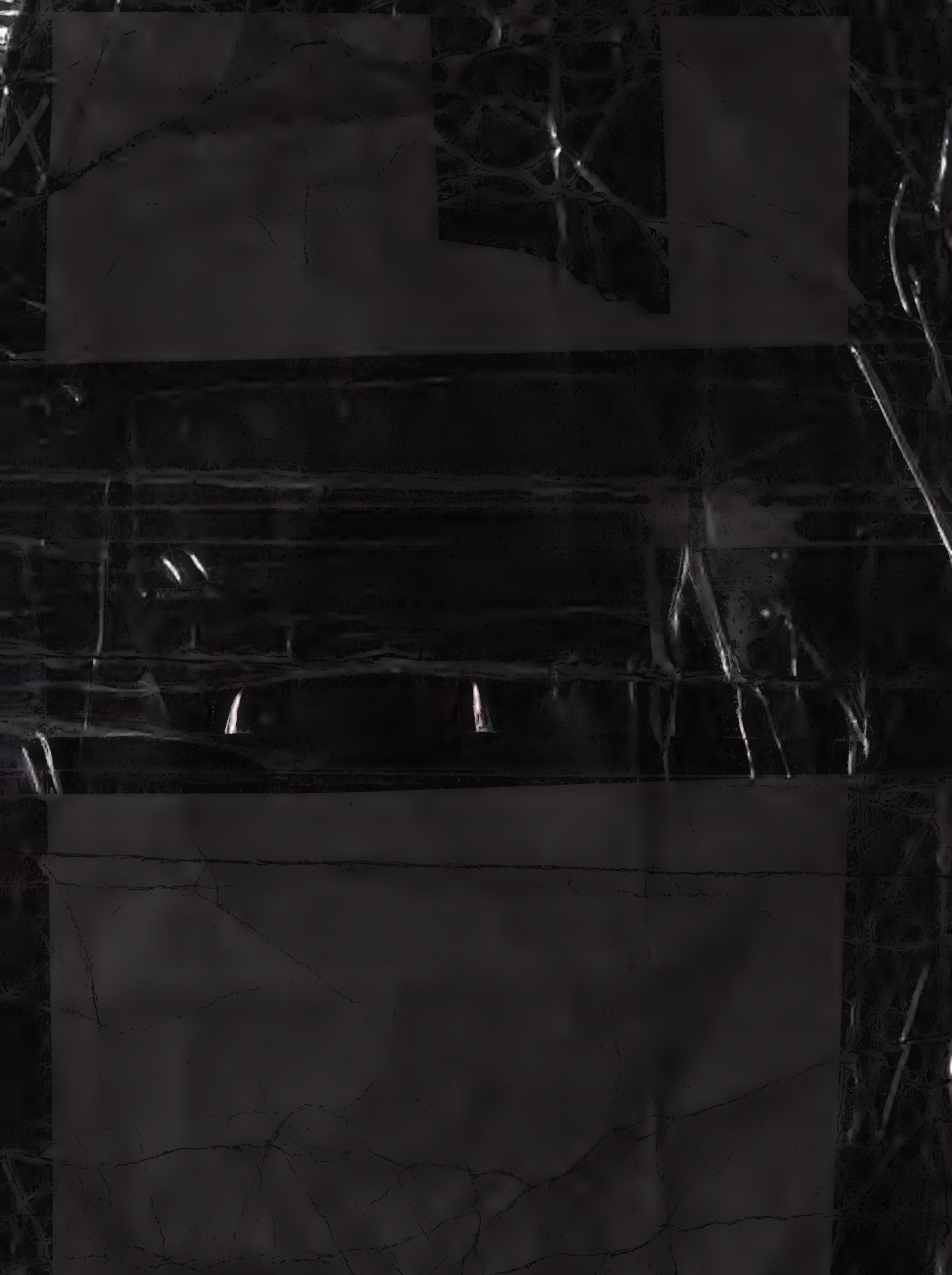
MARKER OSCILL

MODEL 1015

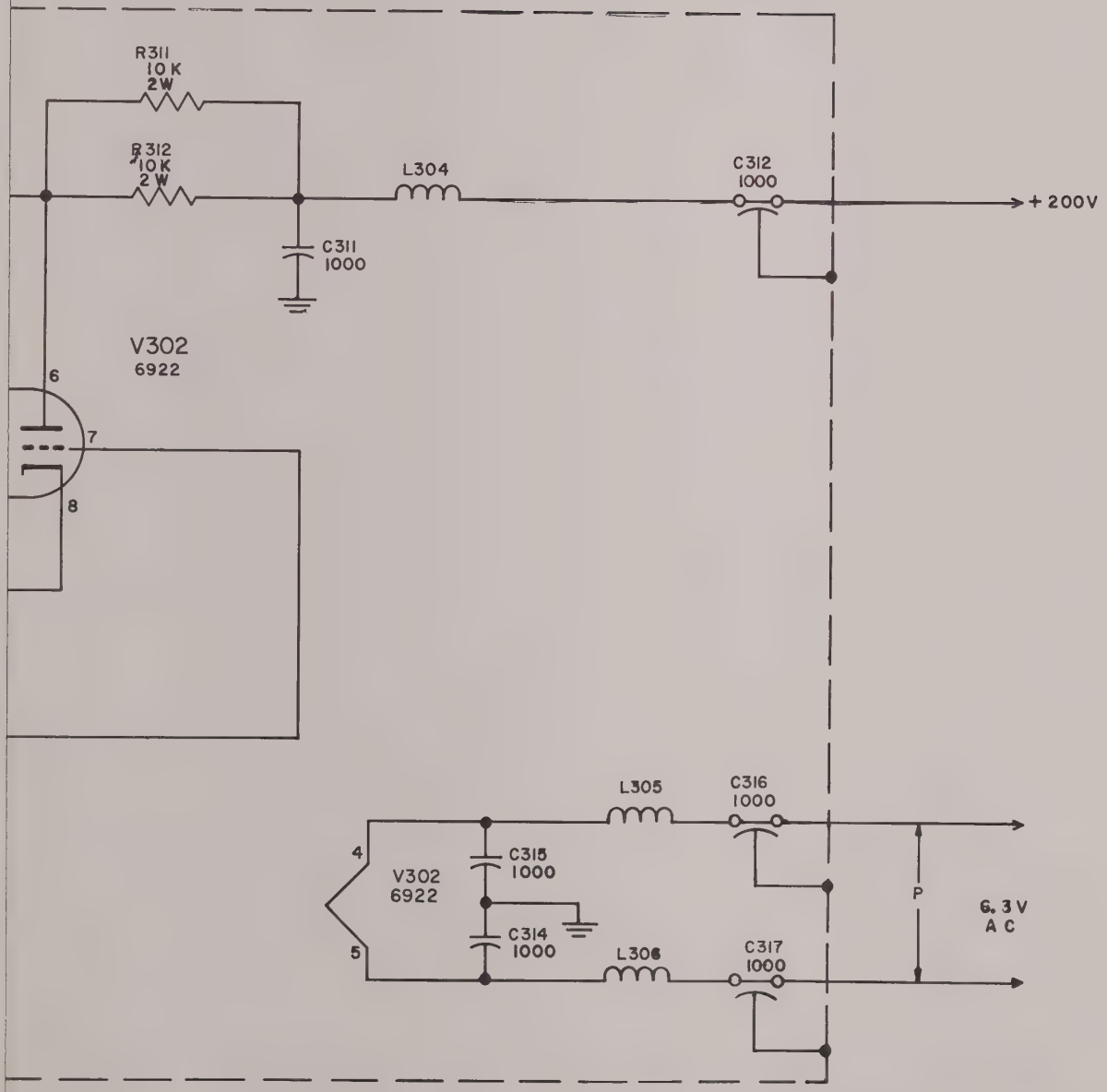


NOTES

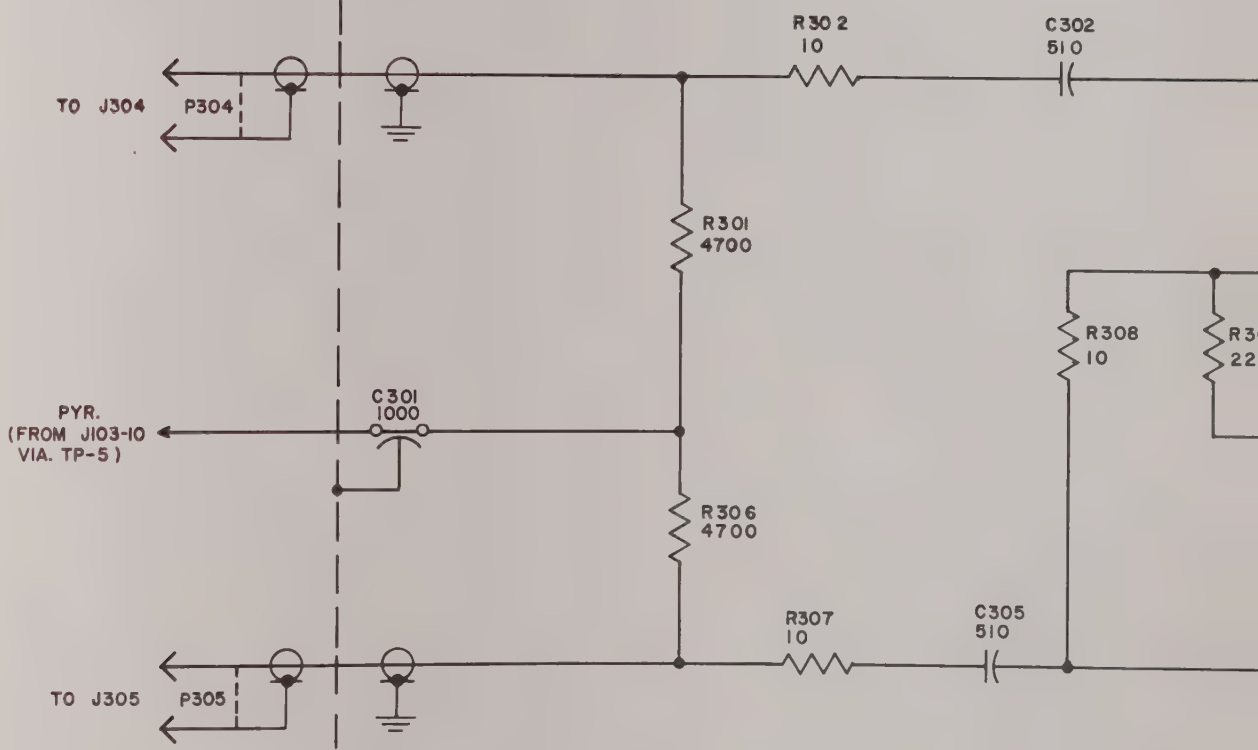
1. ALL RESISTOR VALUES GIVEN IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES GIVEN IN PF UNLESS OTHERWISE SPECIFIED.



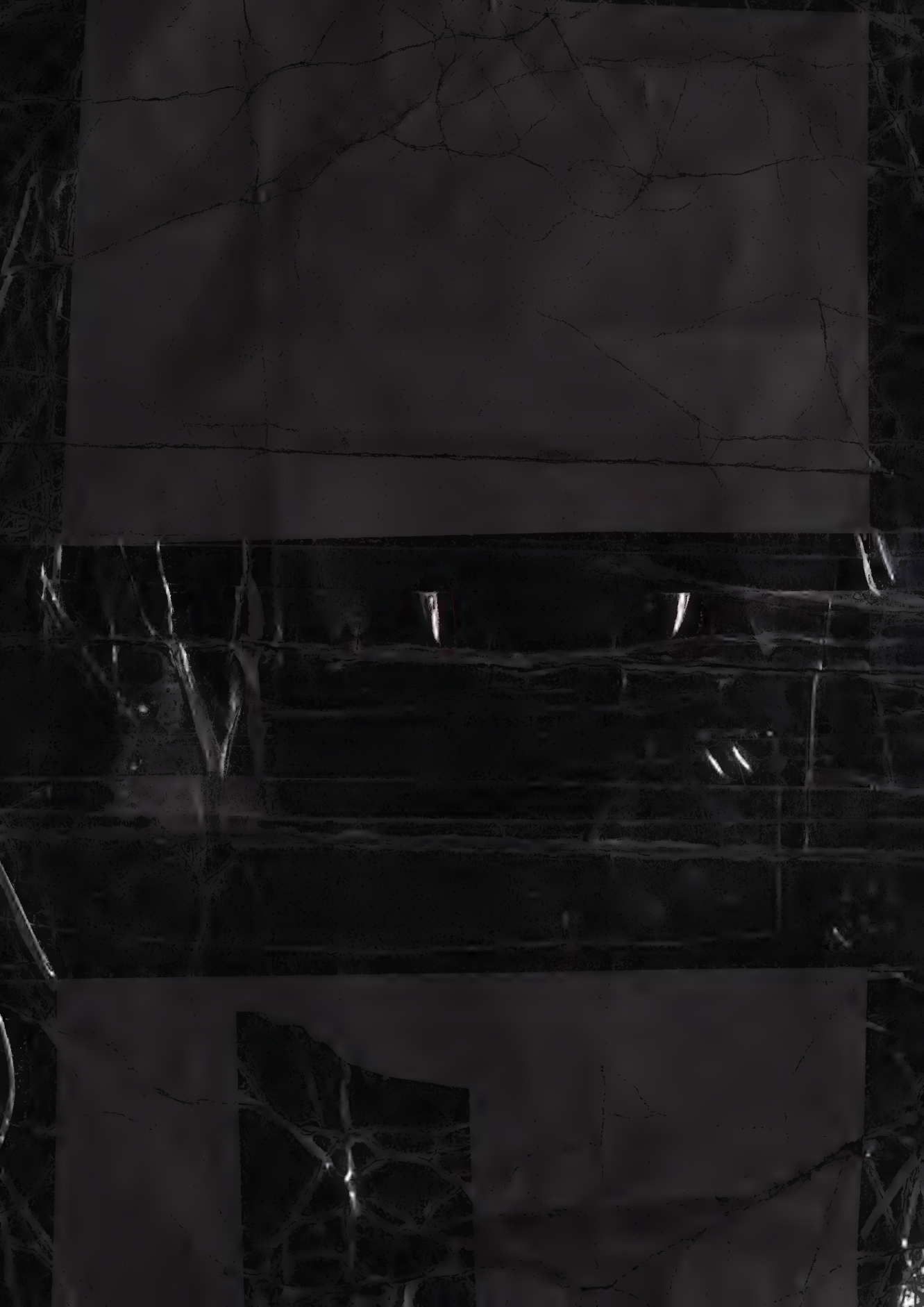
IC
ATOR

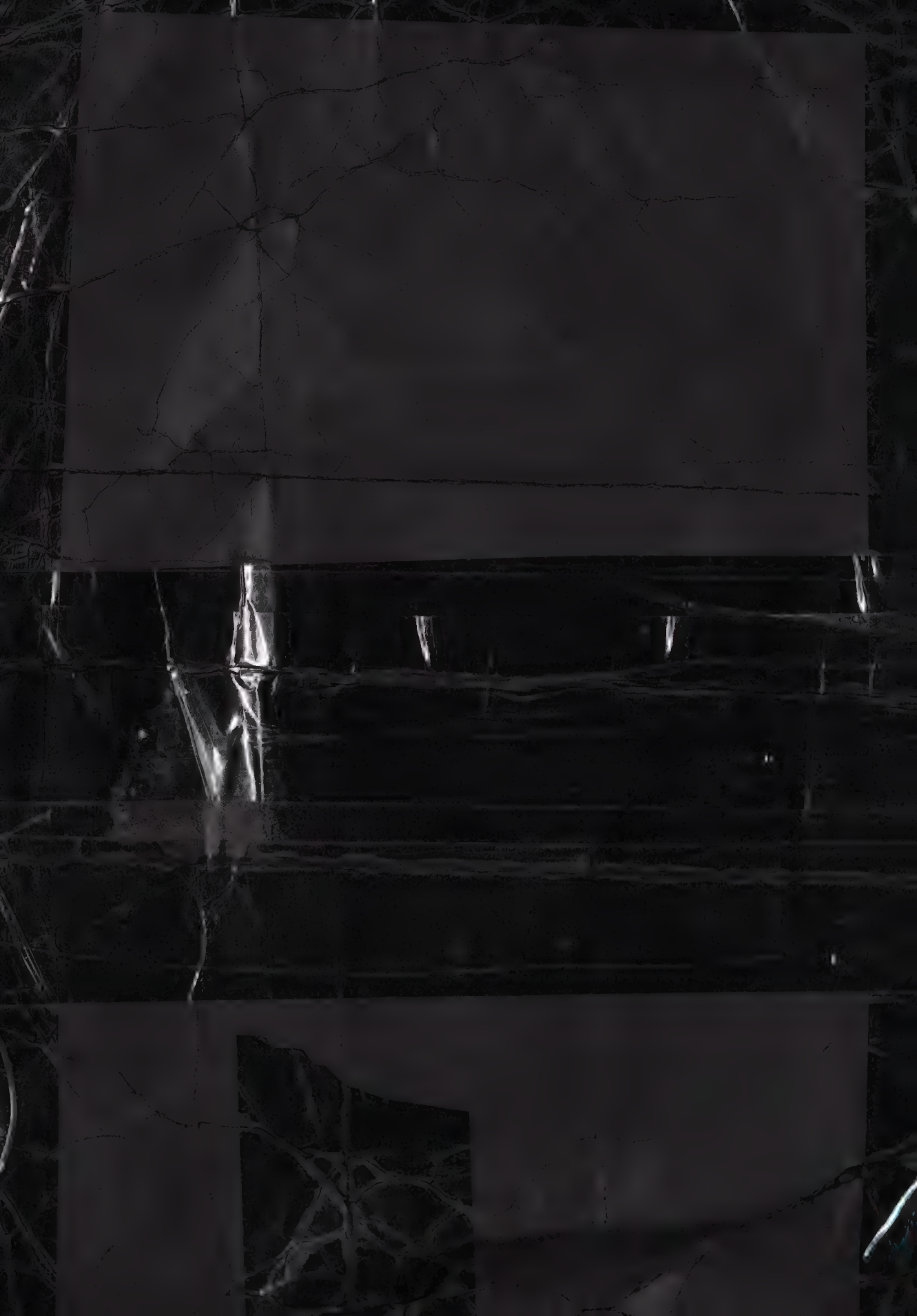

R311
10K
2W
R312
10K
2W
L304
C312
1000
+200V
C311
1000
V302
6922
6
7
8
L305
C316
1000
4
V302
6922
C315
1000
C314
1000
5
L306
C317
1000
P
6.3V
AC

SCHEMA
WIDE SWE
MODEL 101

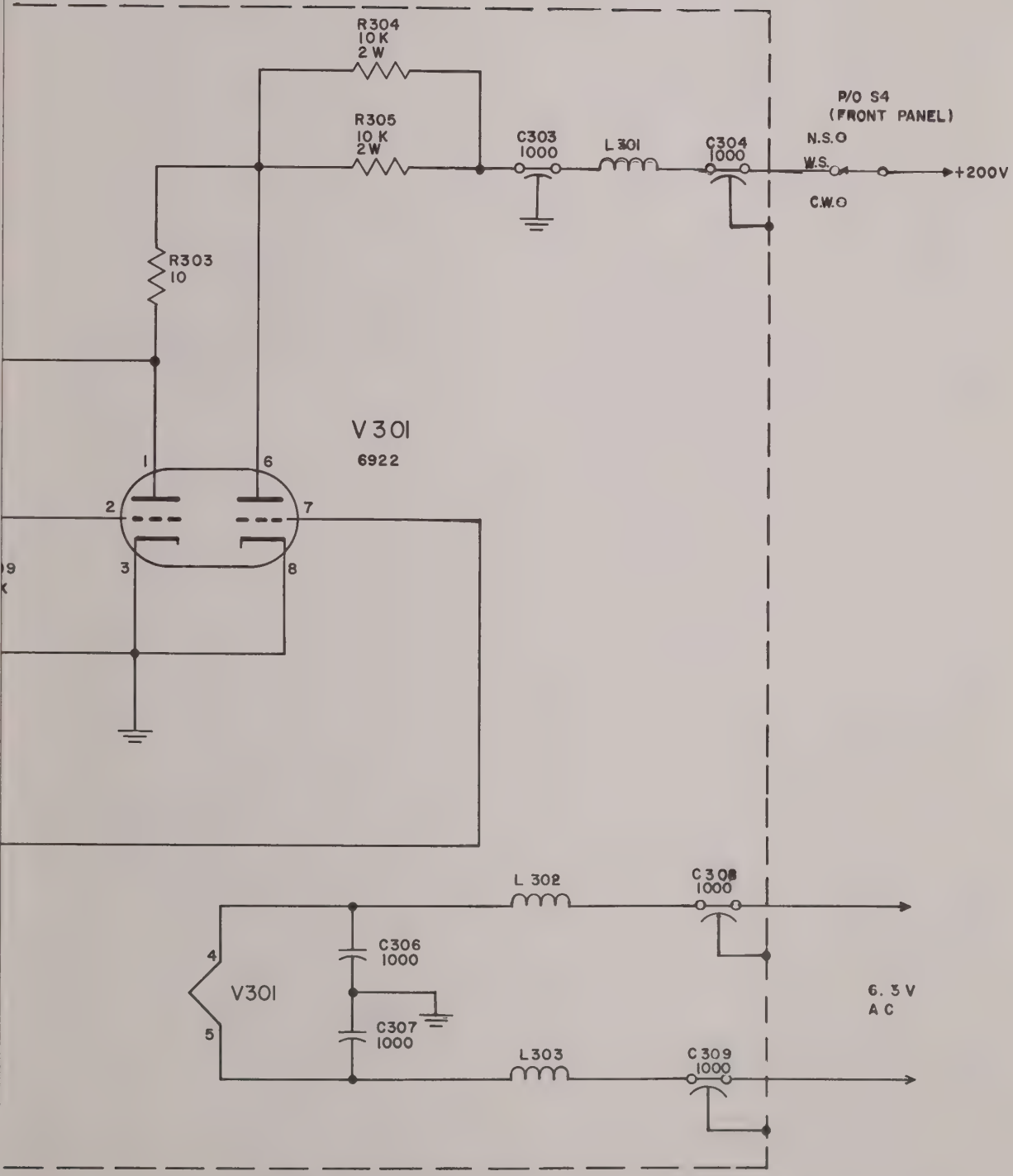


D861—449



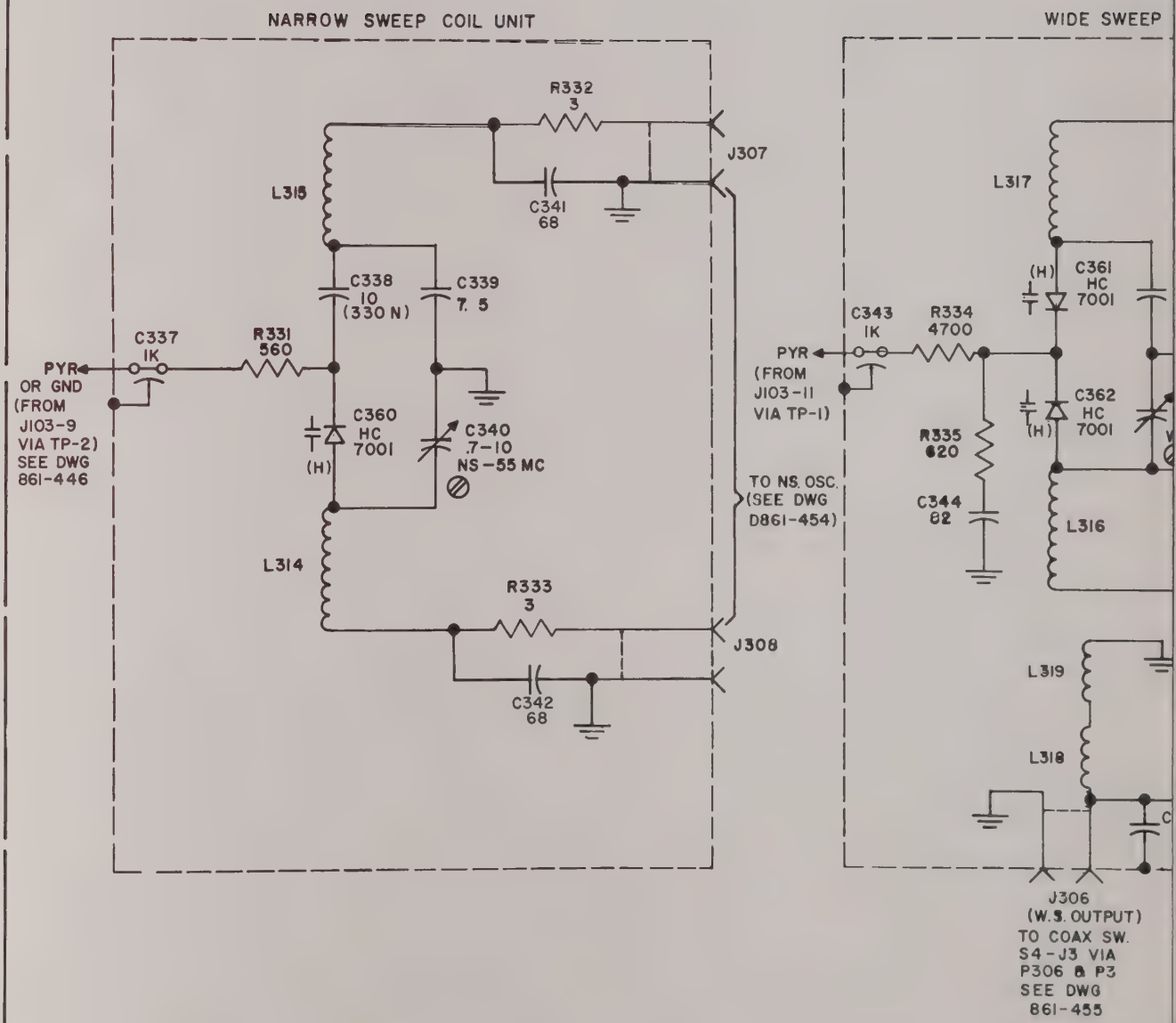


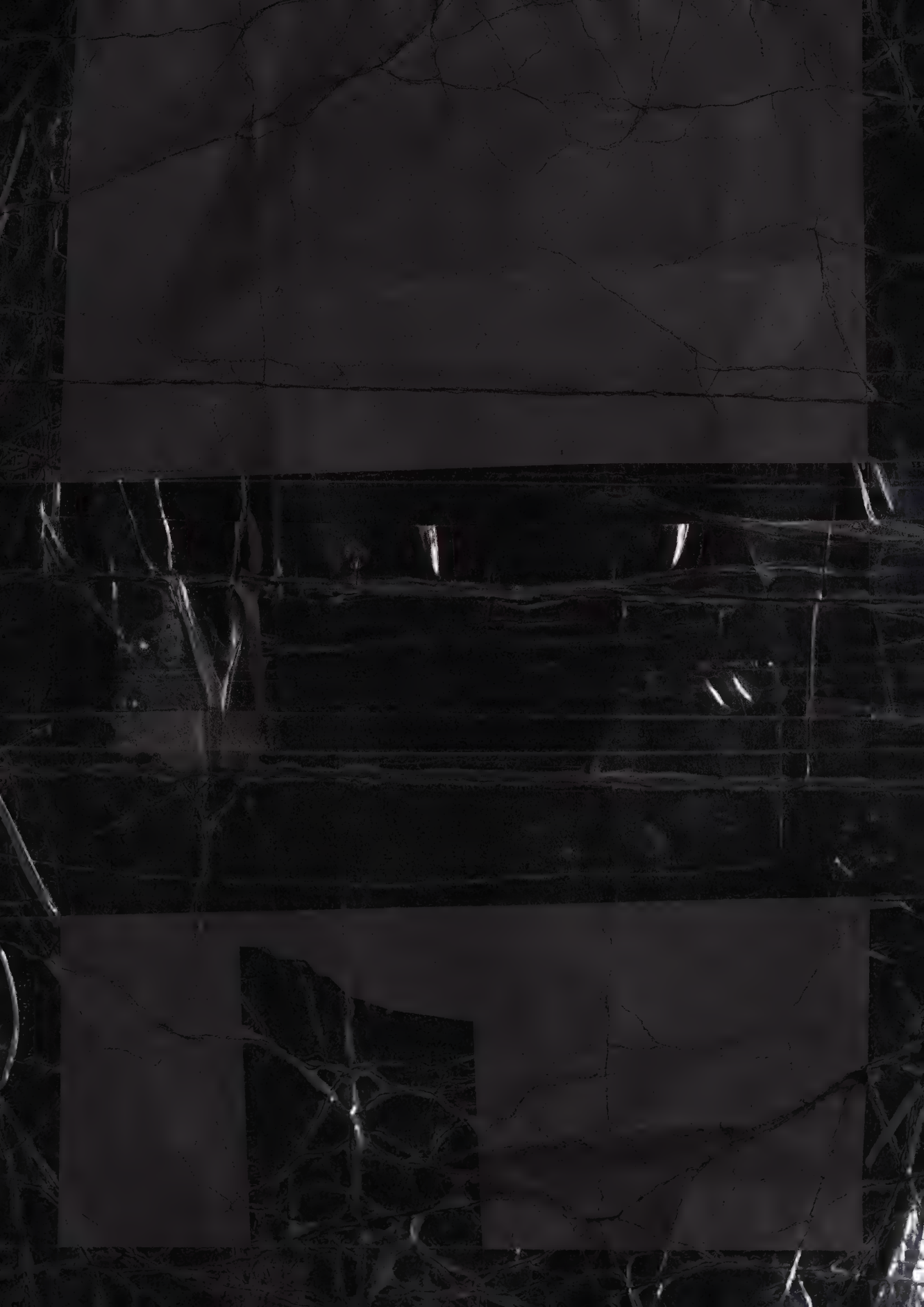
ATIC
EP OSC.



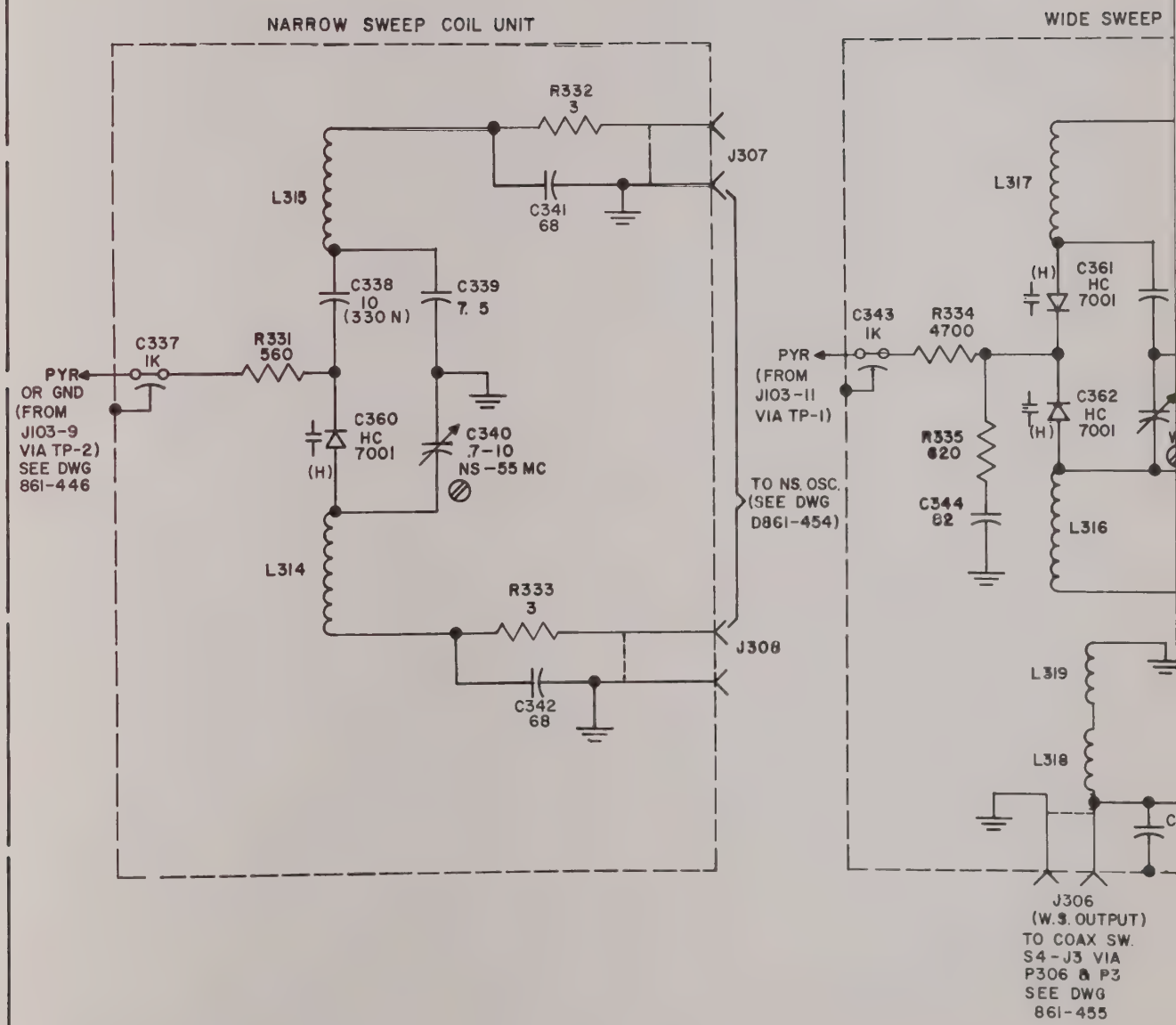
NOTES:
1. ALL RESISTOR VALUES GIVEN IN OHMS, 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES GIVEN IN PF UNLESS OTHERWISE SPECIFIED.

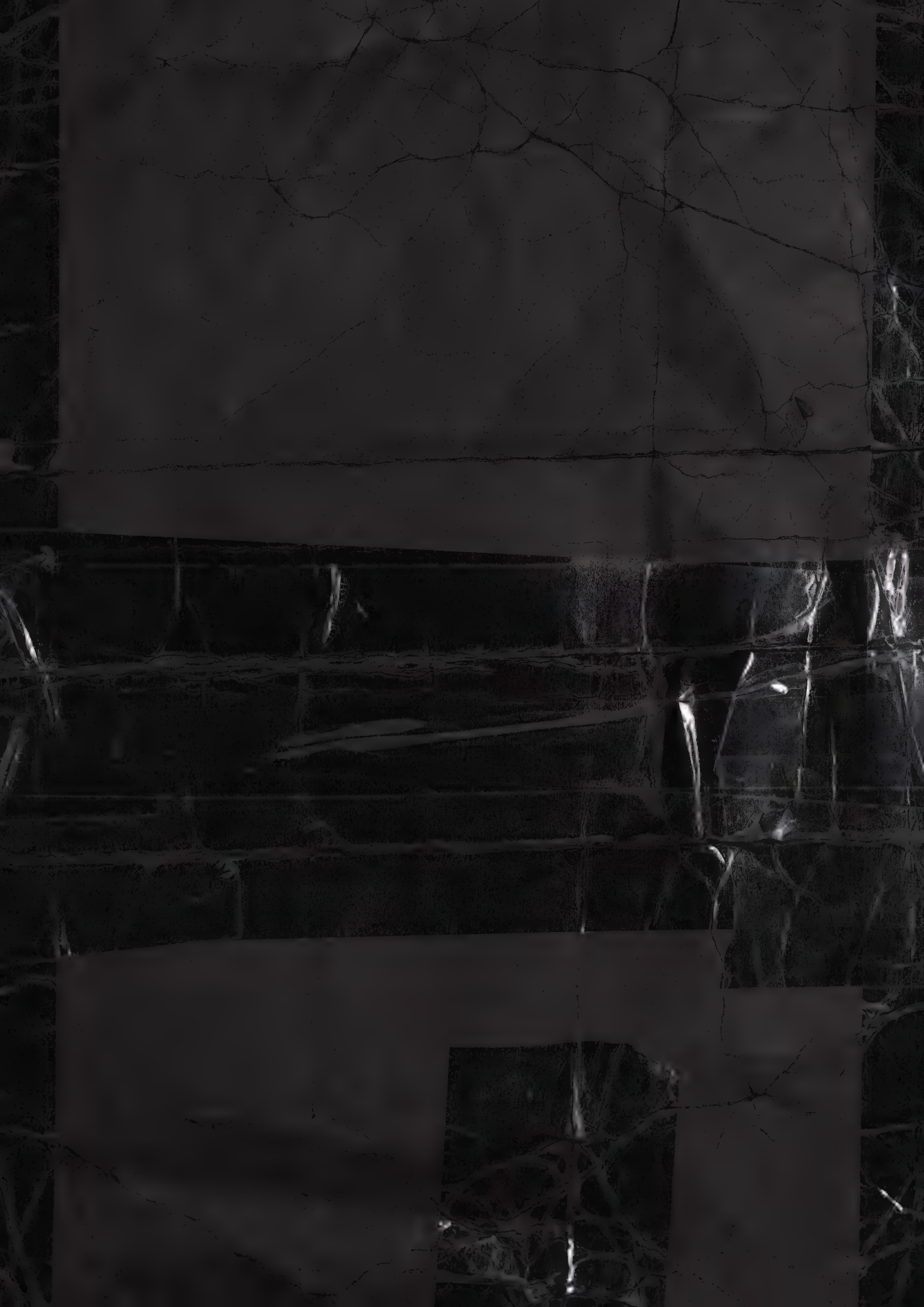
SC
OSCILLATOR

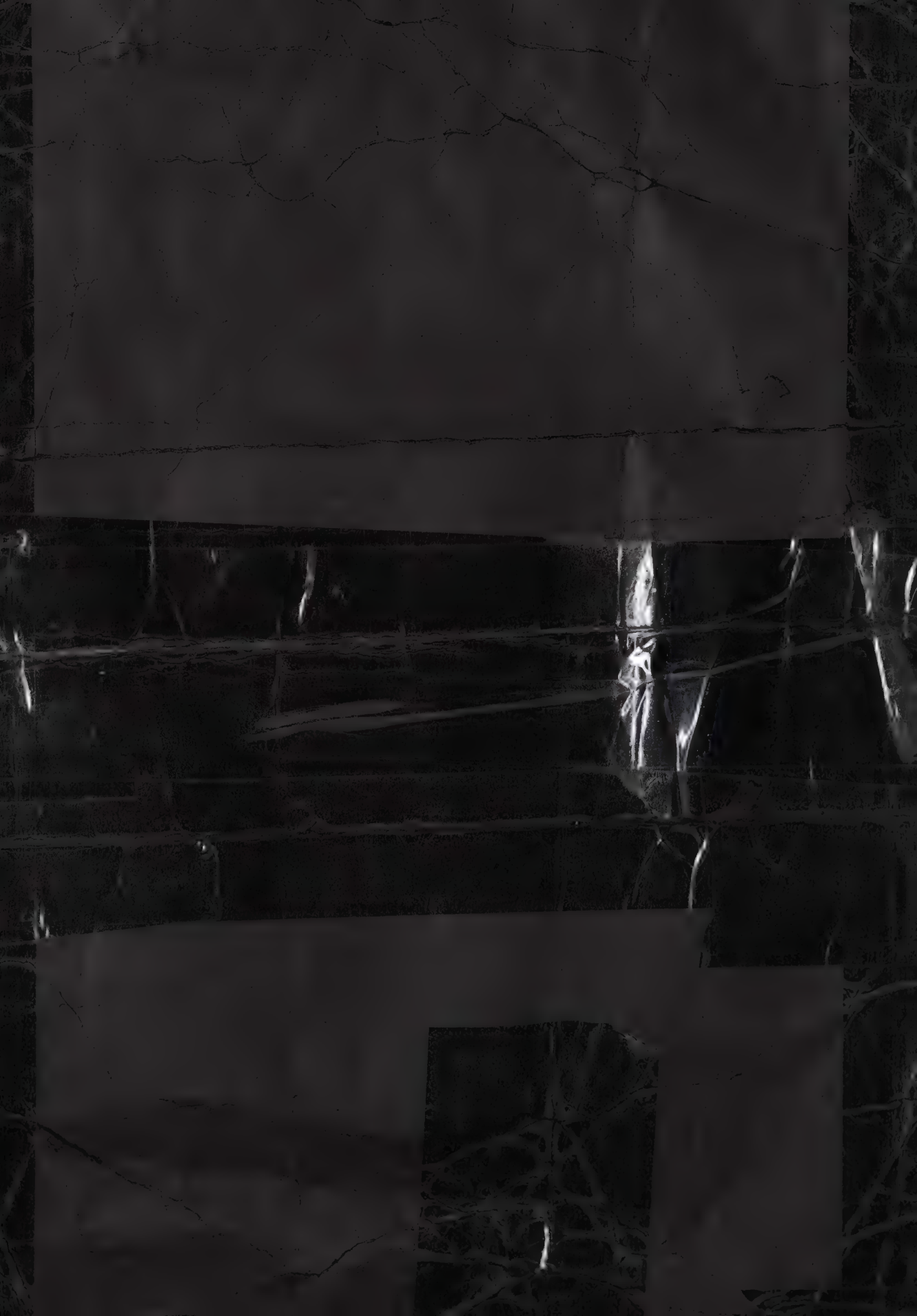




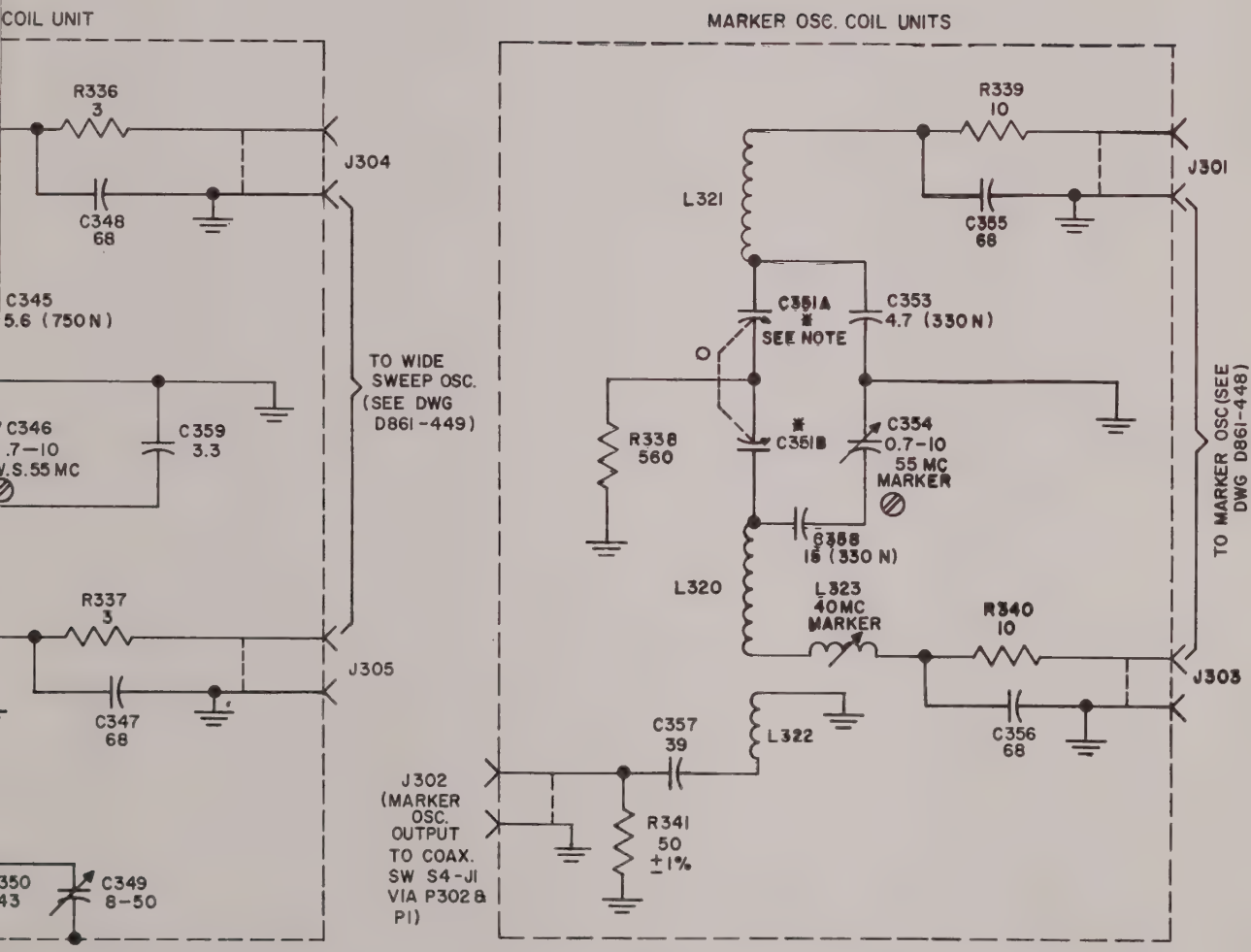
SC
OSCILLATOR







HEMATIC
COIL ASSEMBLY

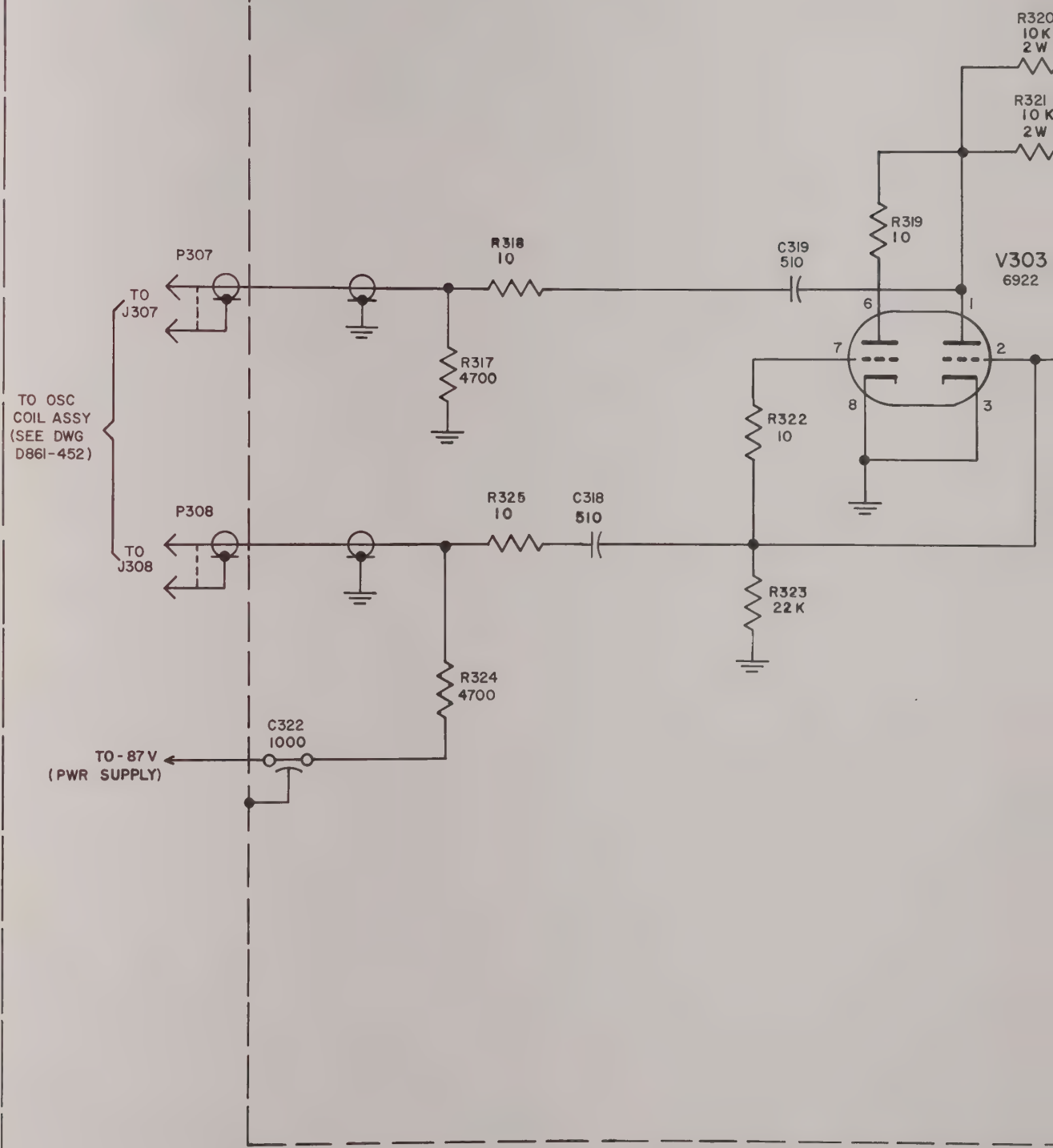


* CAPACITOR IS HAMMARLUND MCD-35 MX WITH 4 ROTOR & 4 STATOR PLATES.

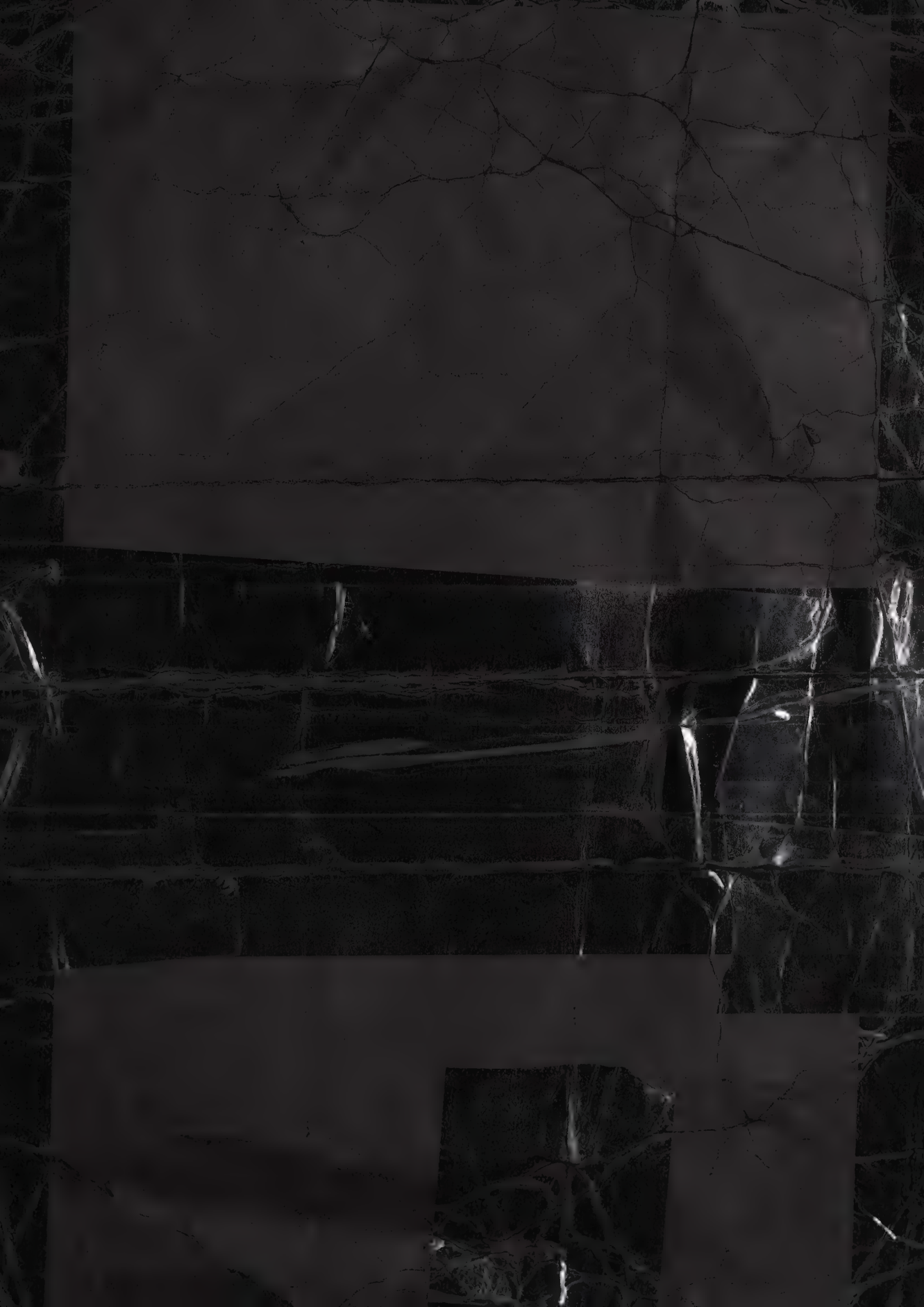
NOTES

1. ALL RESISTOR VALUES IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES IN PF UNLESS OTHERWISE SPECIFIED.

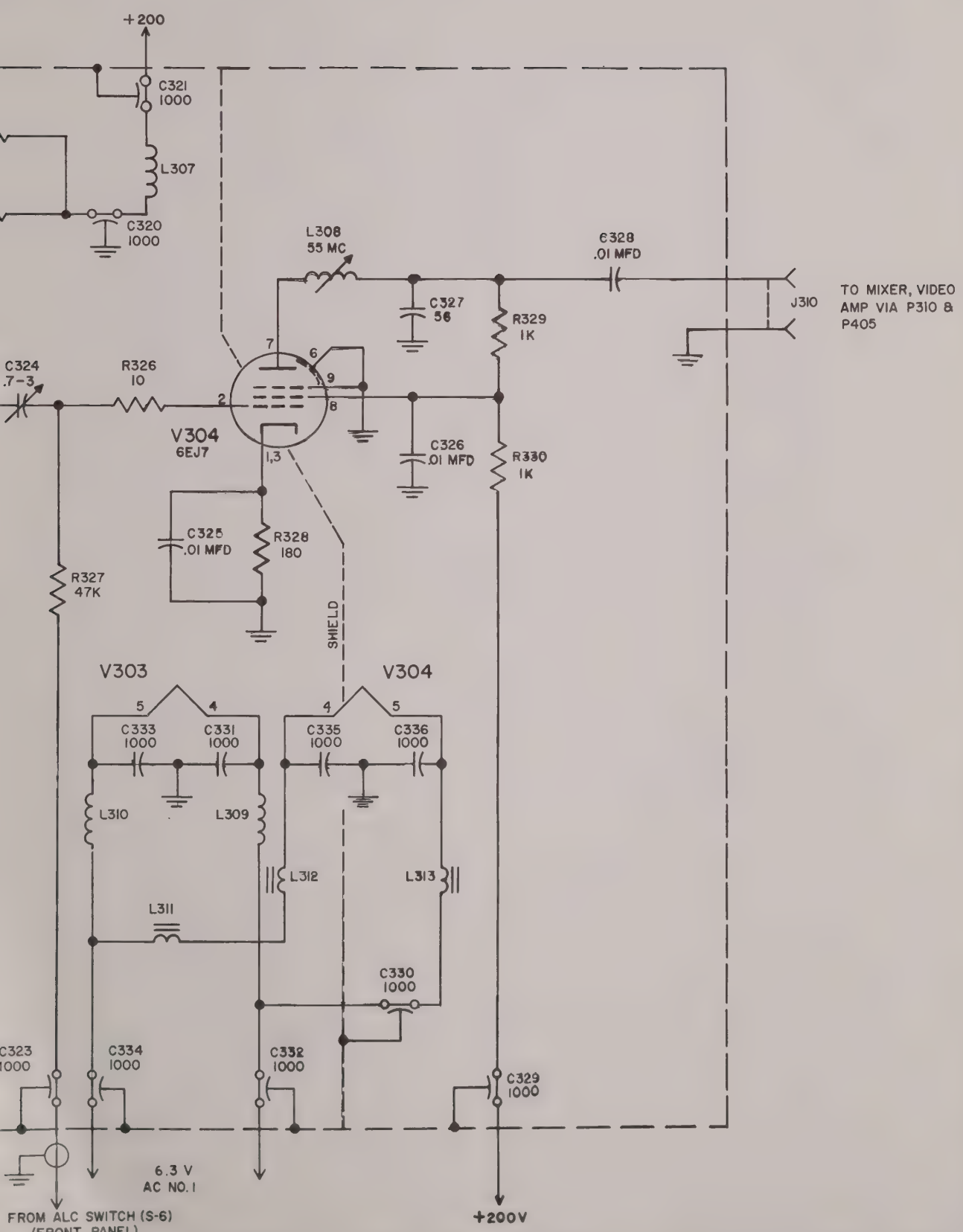
SC
NARROW
MO

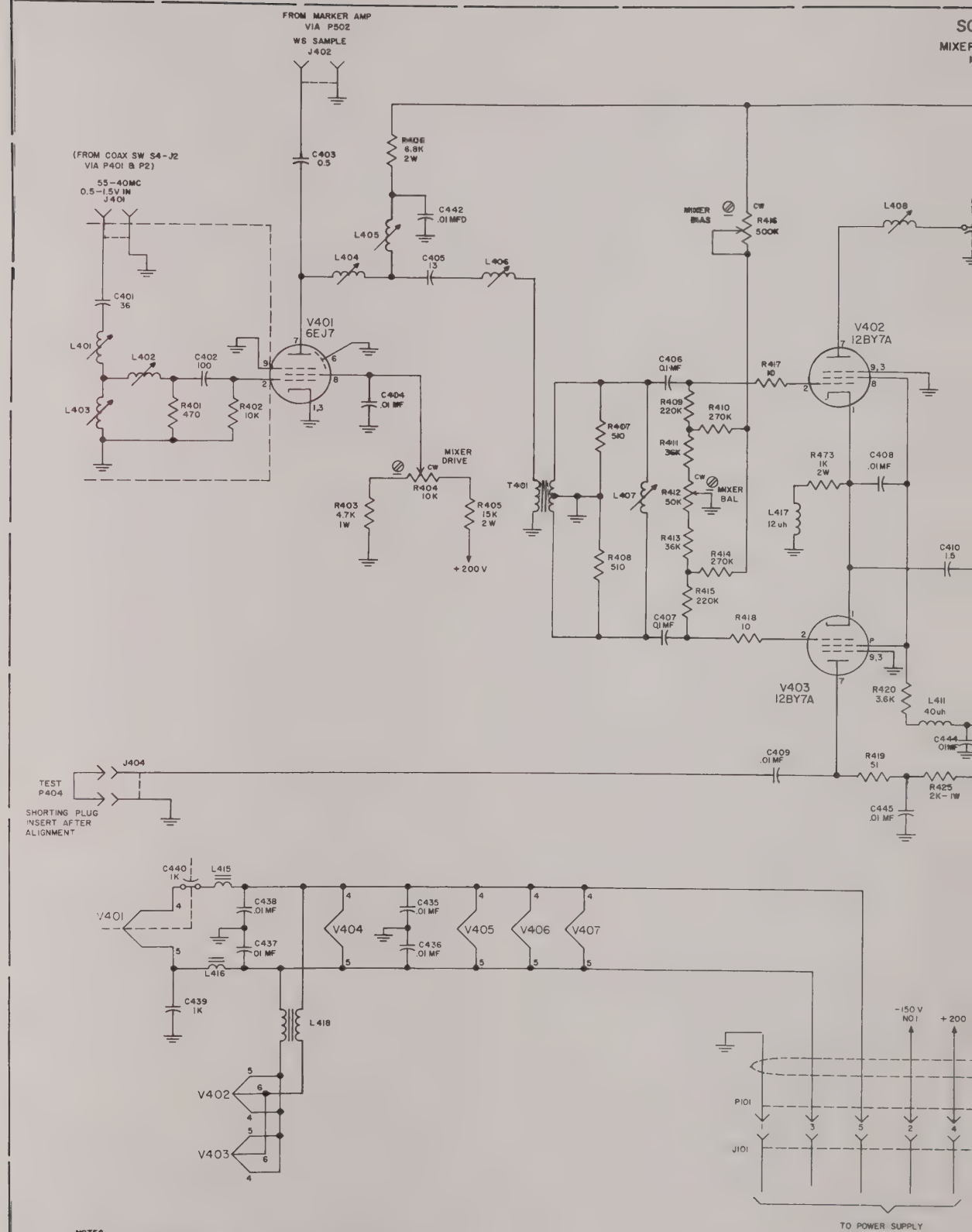


NOTES:
1. ALL RESISTOR VALUES IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES IN PF UNLESS OTHERWISE SPECIFIED.



HEMATIC
SWEEP OSCILLATOR
DEL 1015

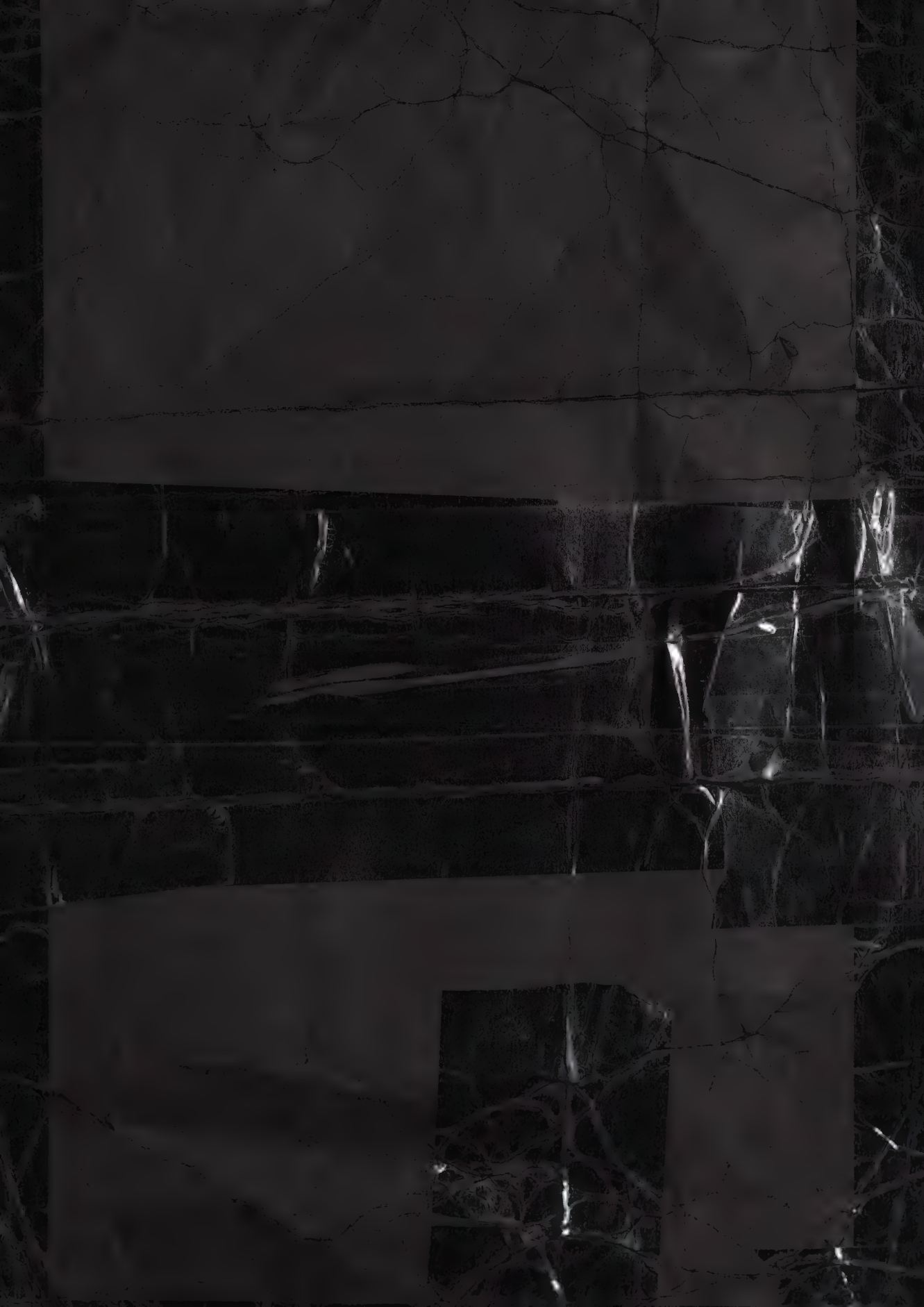


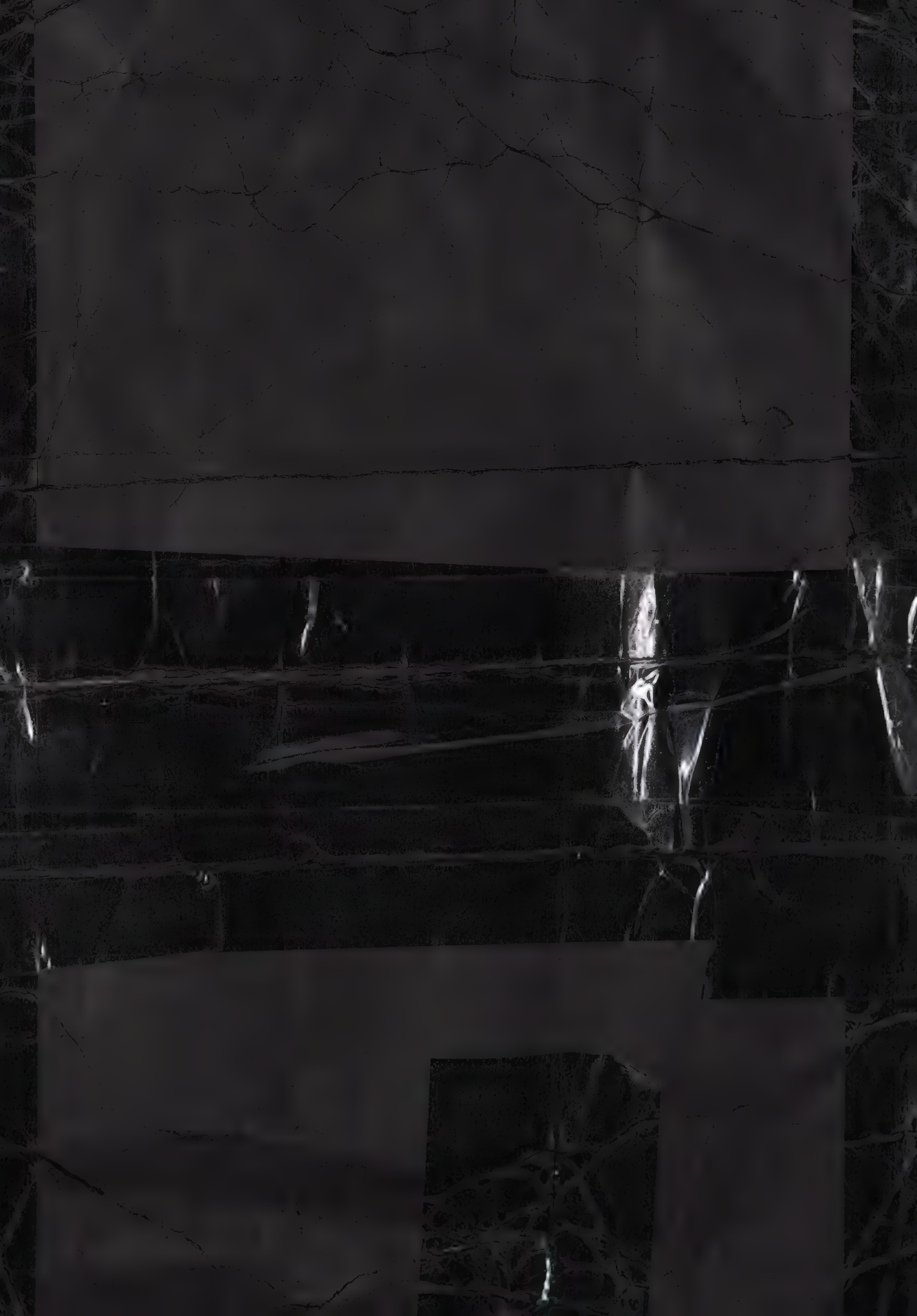


NOTES

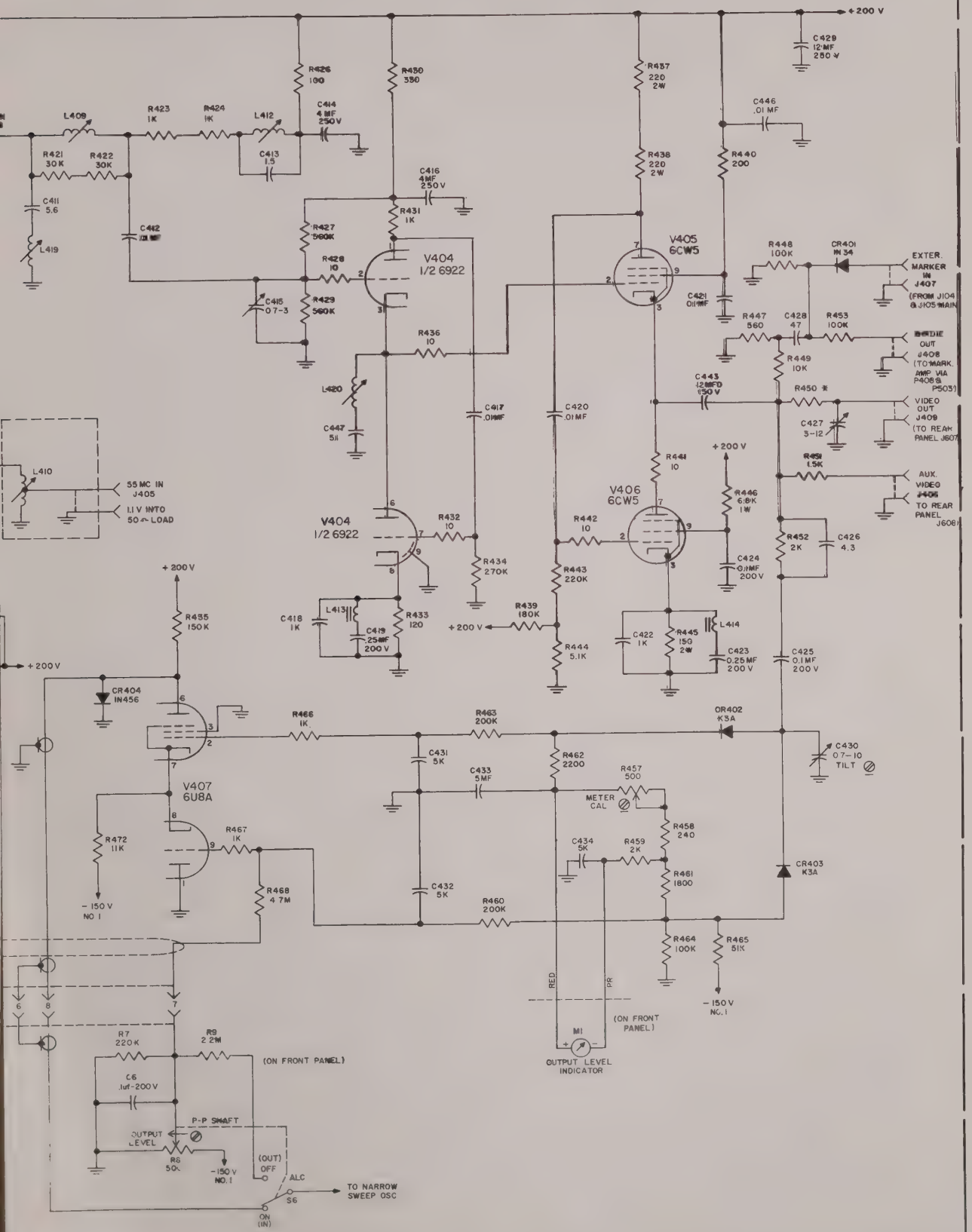
1. ALL RESISTOR VALUES GIVEN IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES GIVEN IN PF, UNLESS OTHERWISE SPECIFIED.
3. ⊘ = INTERNAL ADJ.

■ 50 OHM MODEL — R450 — 50 OHM, 1/2 W, 1%
75 OHM MODEL — R450 — 75 OHM, 1/2 W, 1%

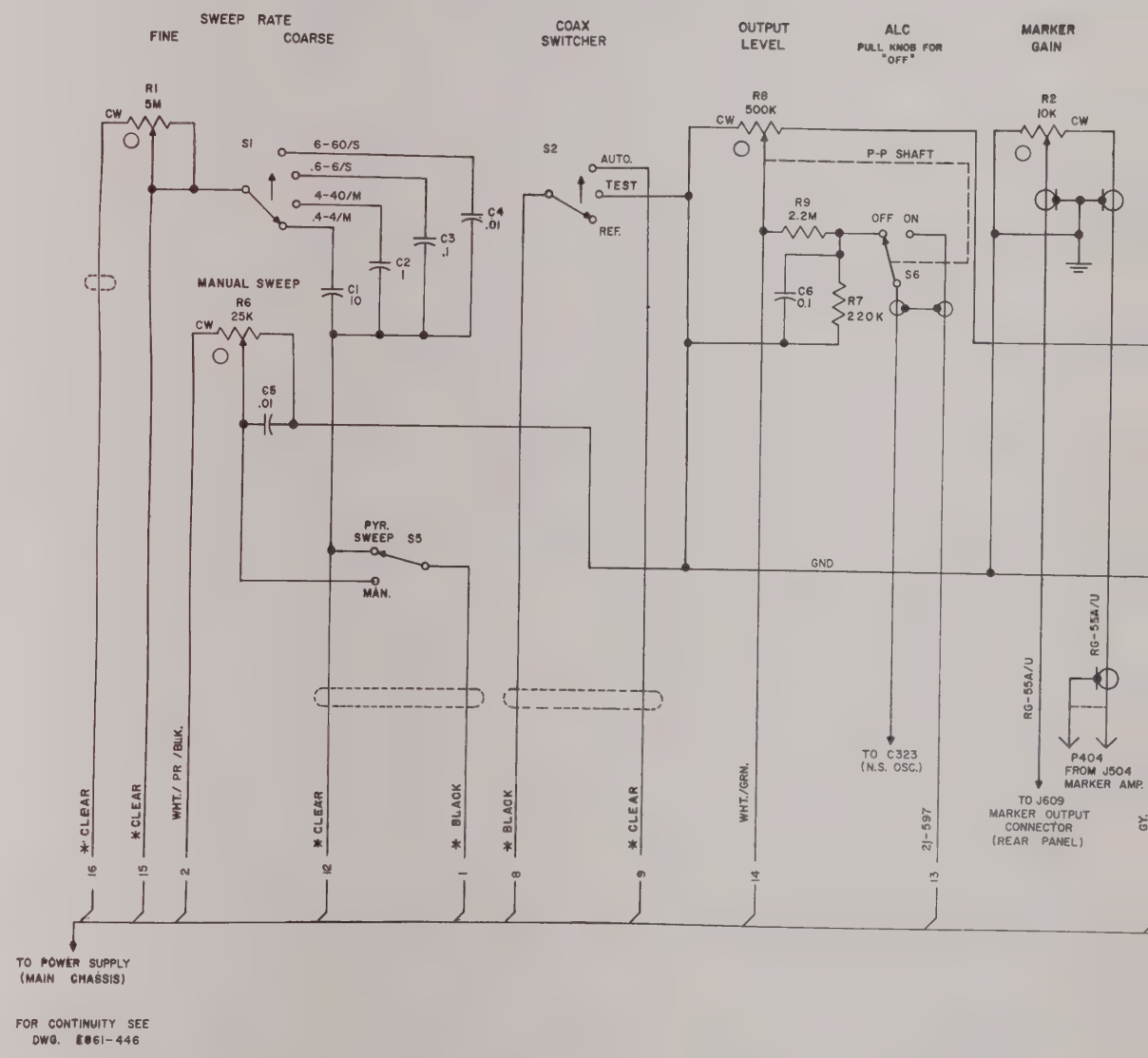


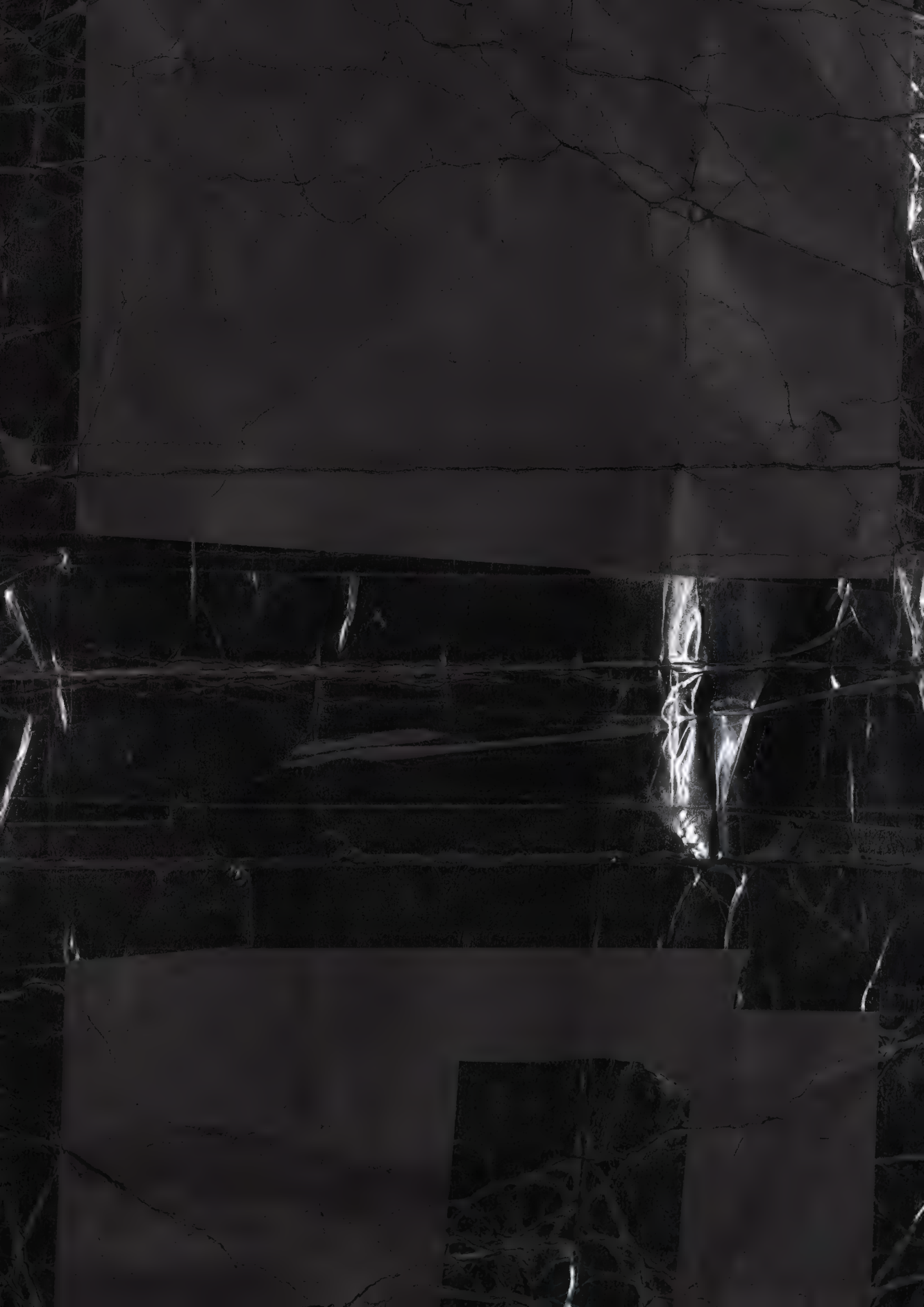


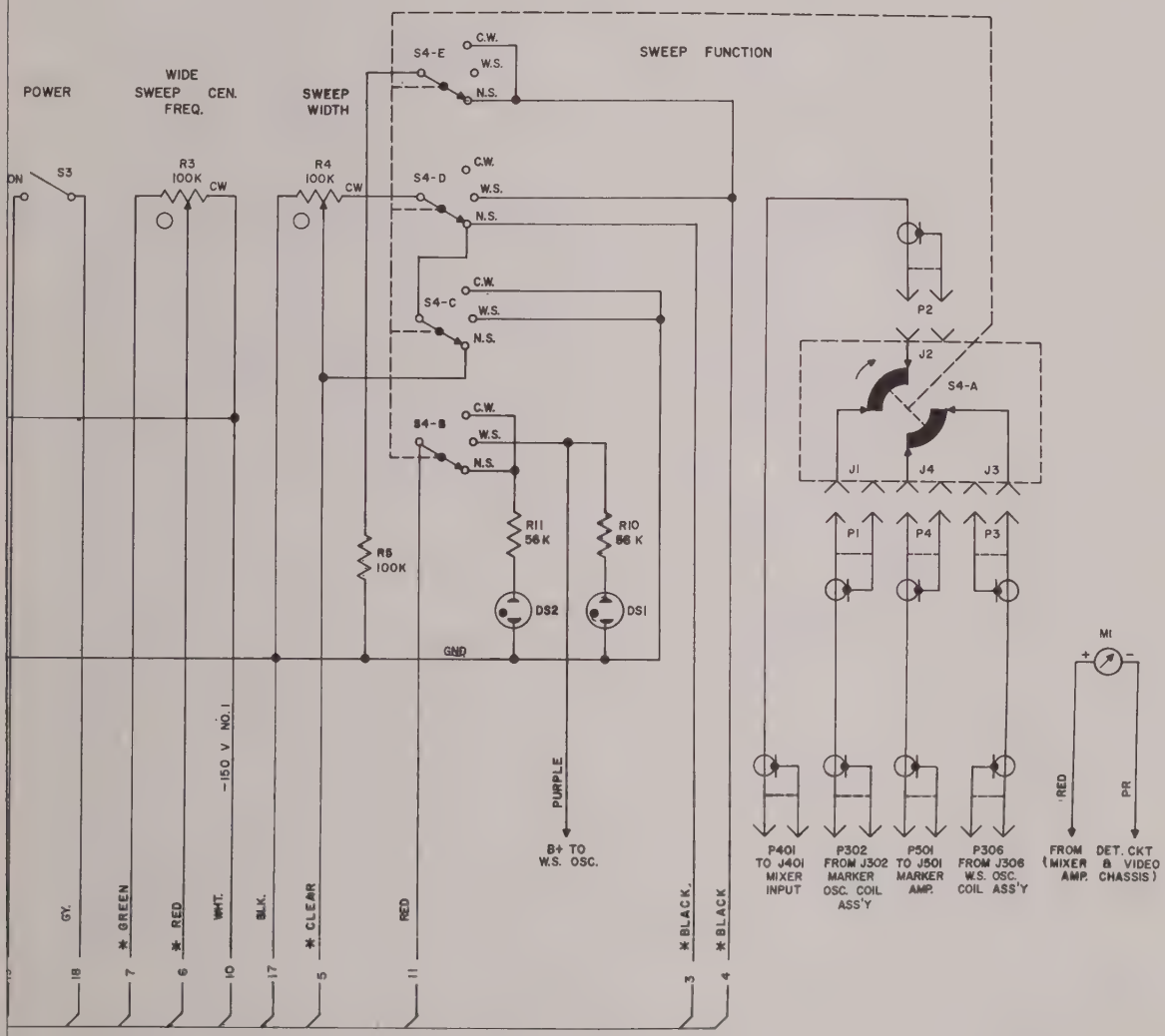
MATIC
VIDEO AMP
EL 1015



SCHEMATIC
FRONT PANEL
MODEL 1015
SERIES B & C







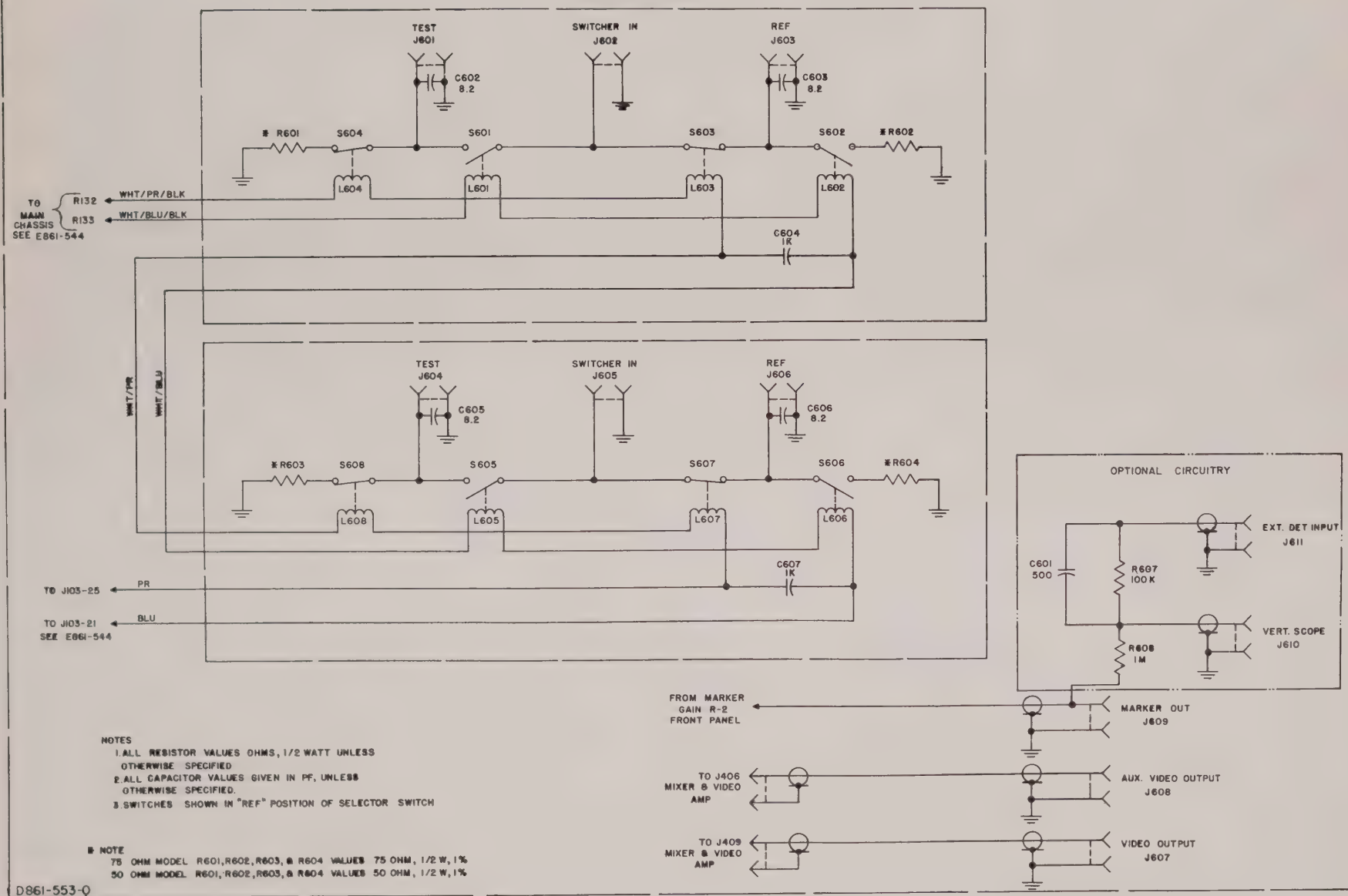
NOTES:

1. ALL RESISTOR VALUES IN OHMS, 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES IN MFD. UNLESS OTHERWISE SPECIFIED.
3. ◯ = KNOB CONTROL
   ⊘ = INT. ADJ.
   ⊘ = EXT. ADJ.
4. * - WIRES IN SHIELDED CABLES

COND'S	* WIRE NO'S
1	16
2	1, 12
2	3, 15
2	8, 9
4	4, 5, 6, 7

SCHEMATIC

REAR PANEL
MODEL 1015 SERIES "C"



NOTES
1. ALL RESISTOR VALUES OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITOR VALUES GIVEN IN PF, UNLESS OTHERWISE SPECIFIED.
3. SWITCHES SHOWN IN "REF" POSITION OF SELECTOR SWITCH

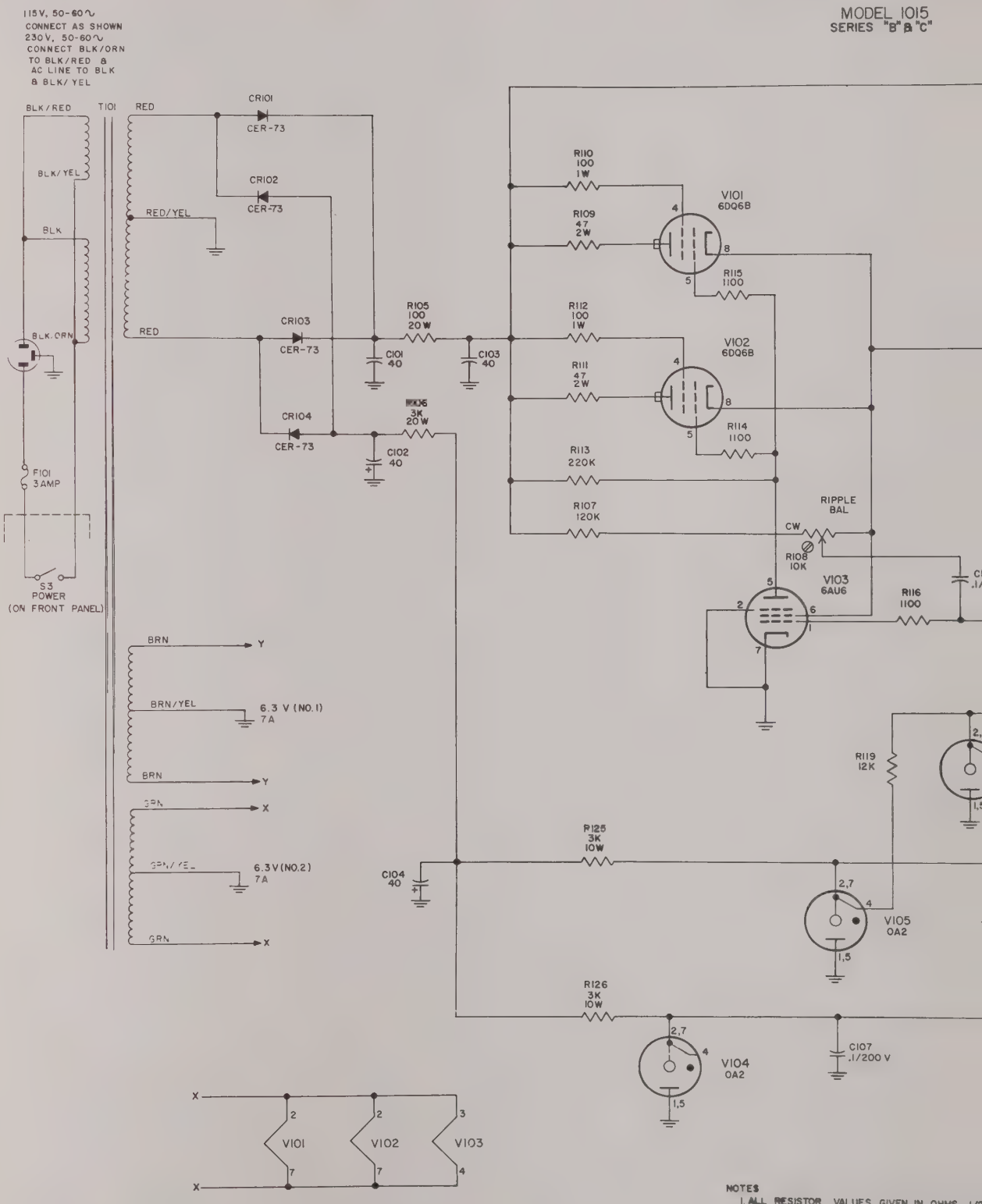
* NOTE
75 OHM MODEL R601, R602, R603, & R604 VALUES 75 OHM, 1/2 W, 1%
50 OHM MODEL R601, R602, R603, & R604 VALUES 50 OHM, 1/2 W, 1%

D861-553-0

SCHEMATIC

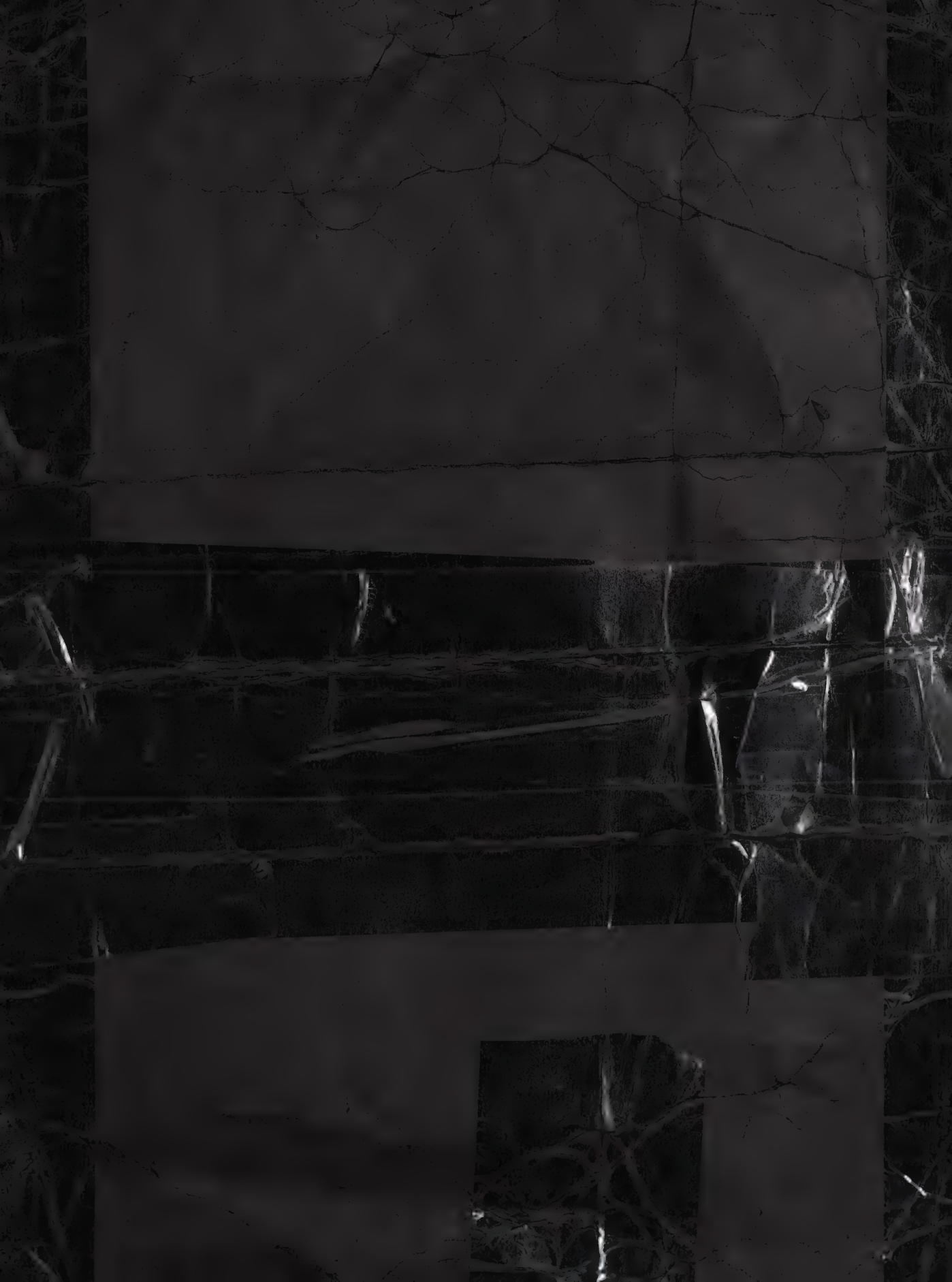
POWER SUPPLY & MAIN CHA

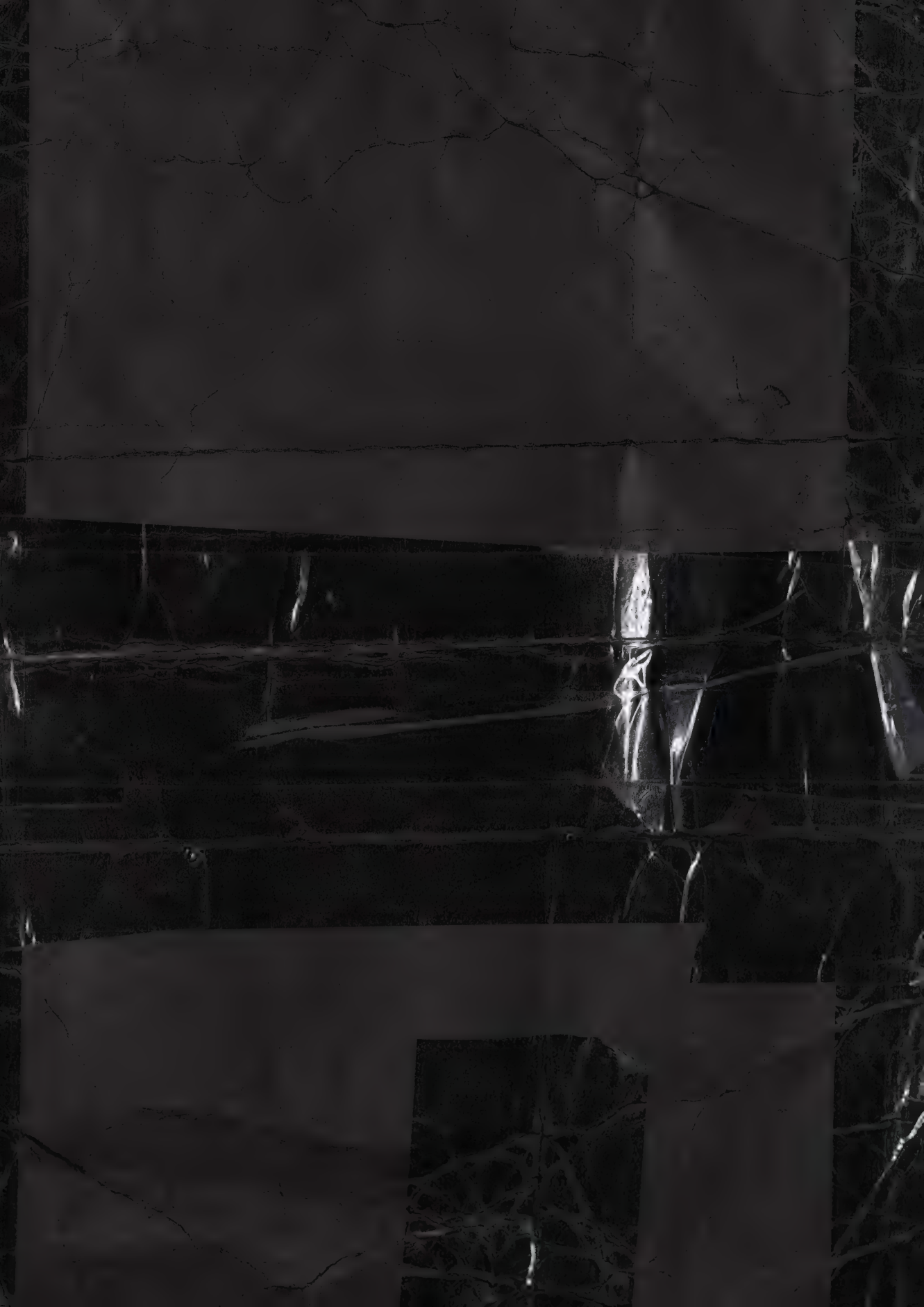
MODEL 1015
SERIES "B" & "C"



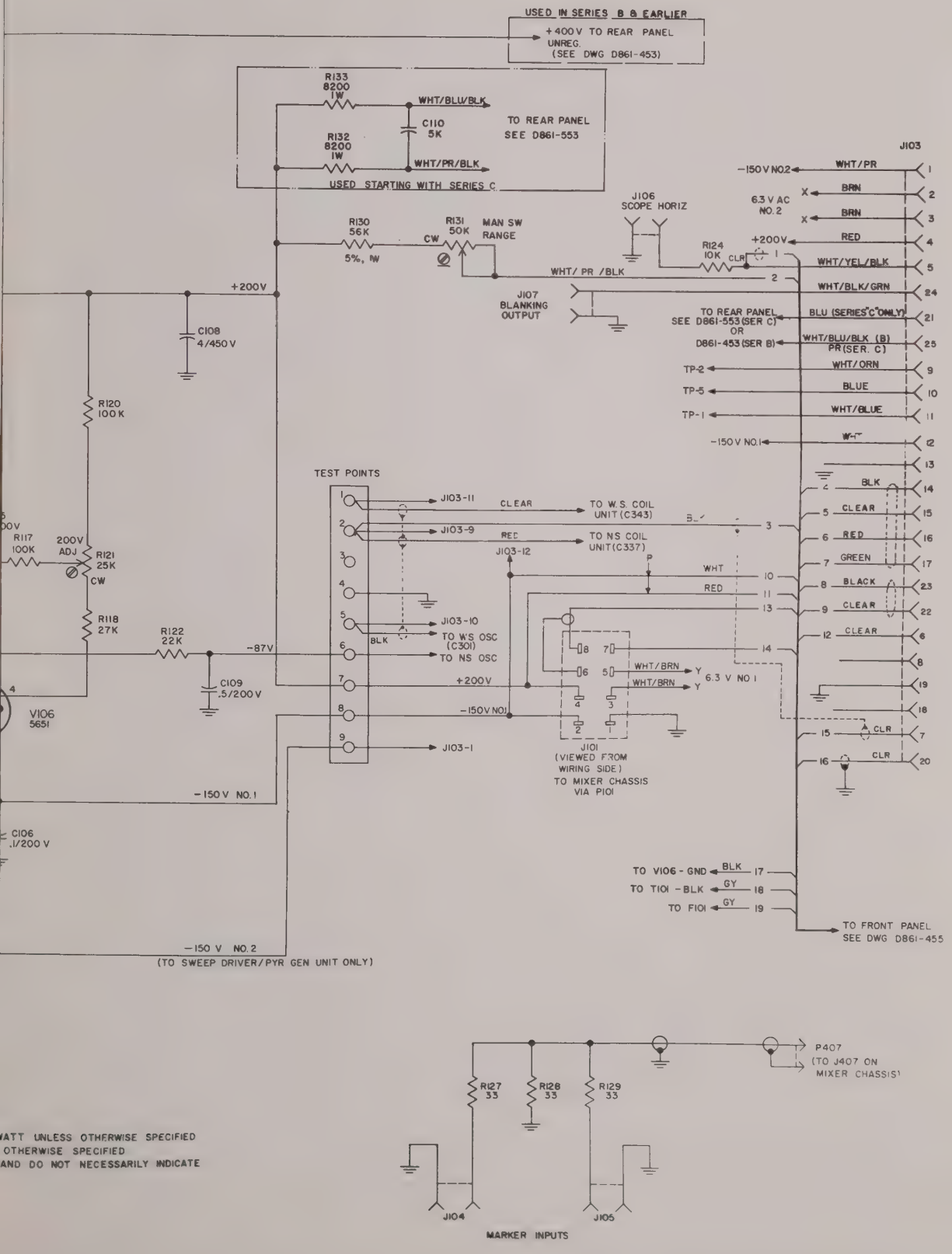
NOTES

1. ALL RESISTOR VALUES GIVEN IN OHMS, 1/2
2. ALL CAPACITOR VALUES GIVEN IN PF UNLES
3. WIRING CHANNELS ARE USED FOR CLARITY CABLING. NUMBERS INDICATE CONTINUITY.
4. ⊘ = EXTERNAL ADJ
   ⊘ = INTERNAL ADJ



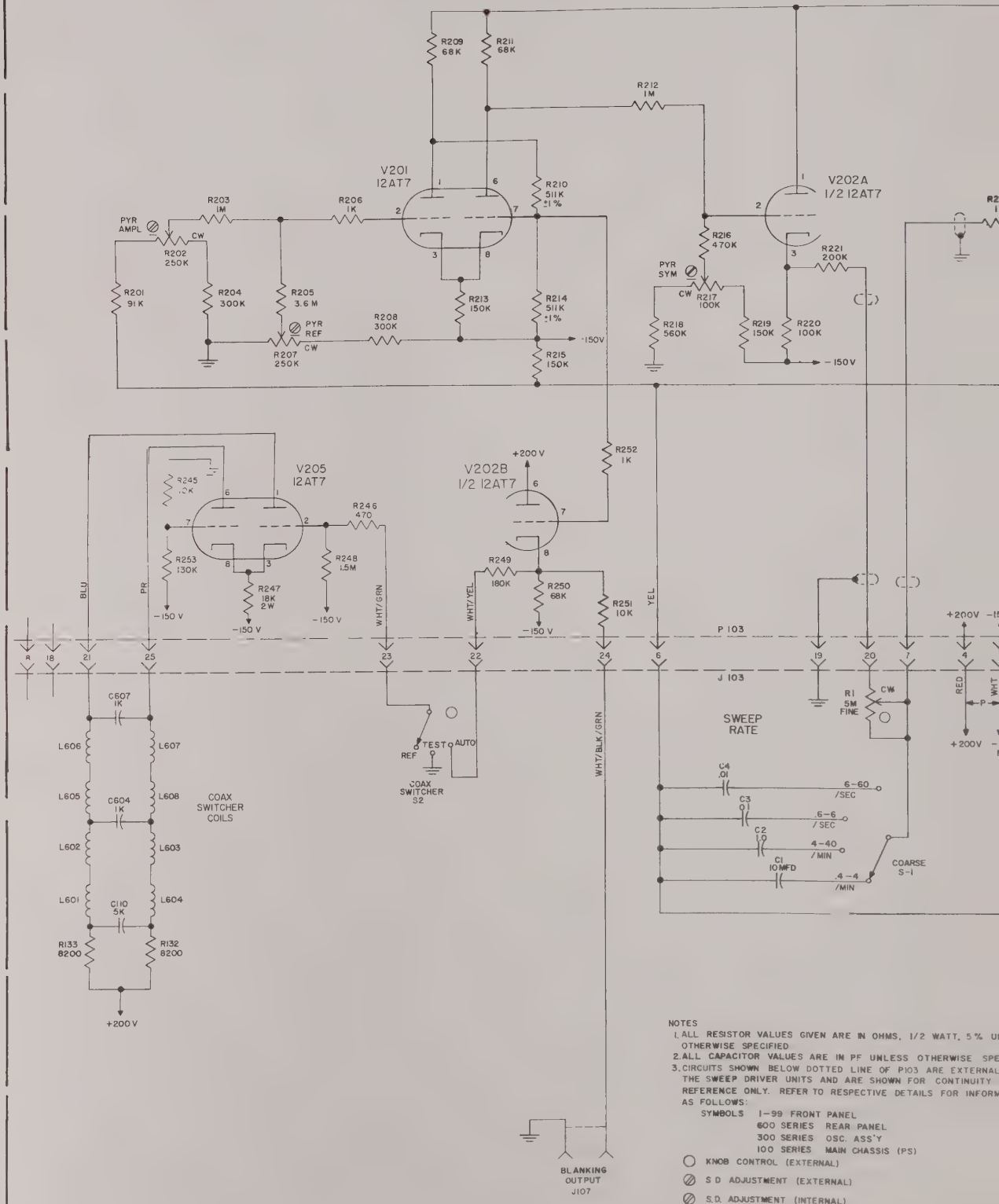


SIS



WATT UNLESS OTHERWISE SPECIFIED
OTHERWISE SPECIFIED
AND DO NOT NECESSARILY INDICATE

SCHE
SWEEP DR
1015 S

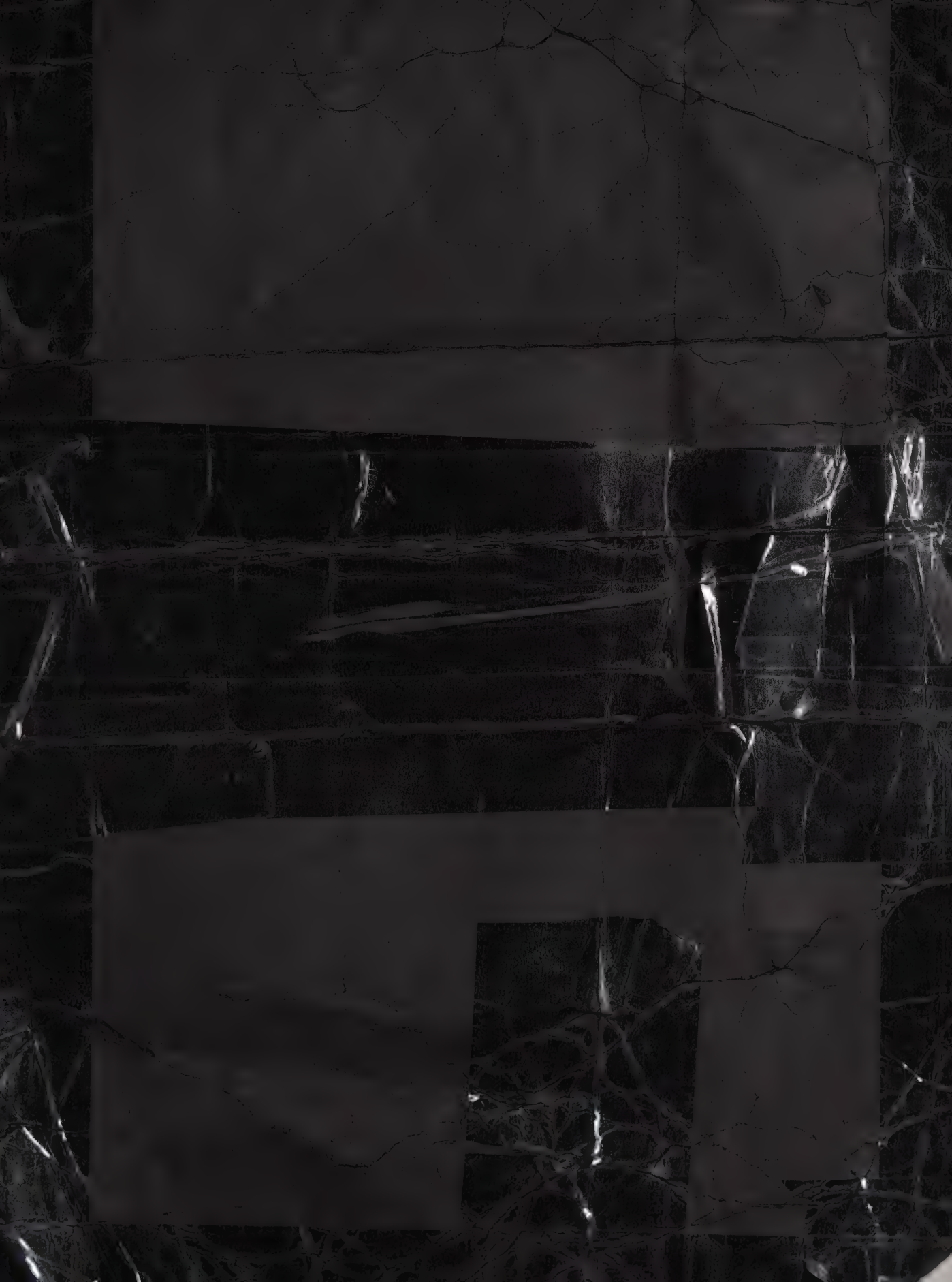


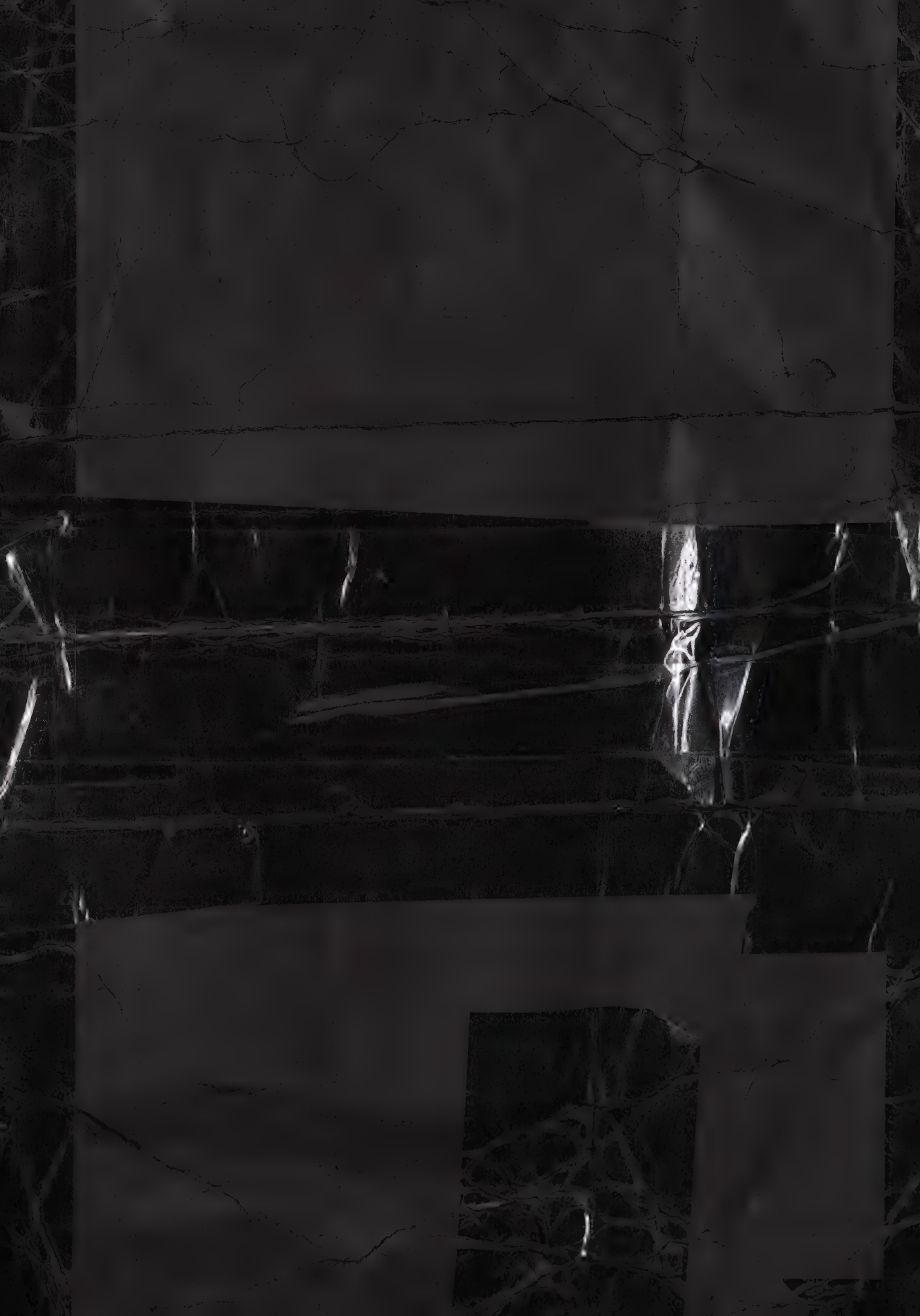
NOTES
1. ALL RESISTOR VALUES GIVEN ARE IN OHMS, 1/2 WATT, 5% U
OTHERWISE SPECIFIED
2. ALL CAPACITOR VALUES ARE IN PF UNLESS OTHERWISE SPE
3. CIRCUITS SHOWN BELOW DOTTED LINE OF P103 ARE EXTERNAL
THE SWEEP DRIVER UNITS AND ARE SHOWN FOR CONTINUITY
REFERENCE ONLY. REFER TO RESPECTIVE DETAILS FOR INFORM
AS FOLLOWS:
SYMBOLS 1-99 FRONT PANEL
600 SERIES REAR PANEL
300 SERIES OSC. ASS'Y
100 SERIES MAIN CHASSIS (PS)

○ KNOB CONTROL (EXTERNAL)

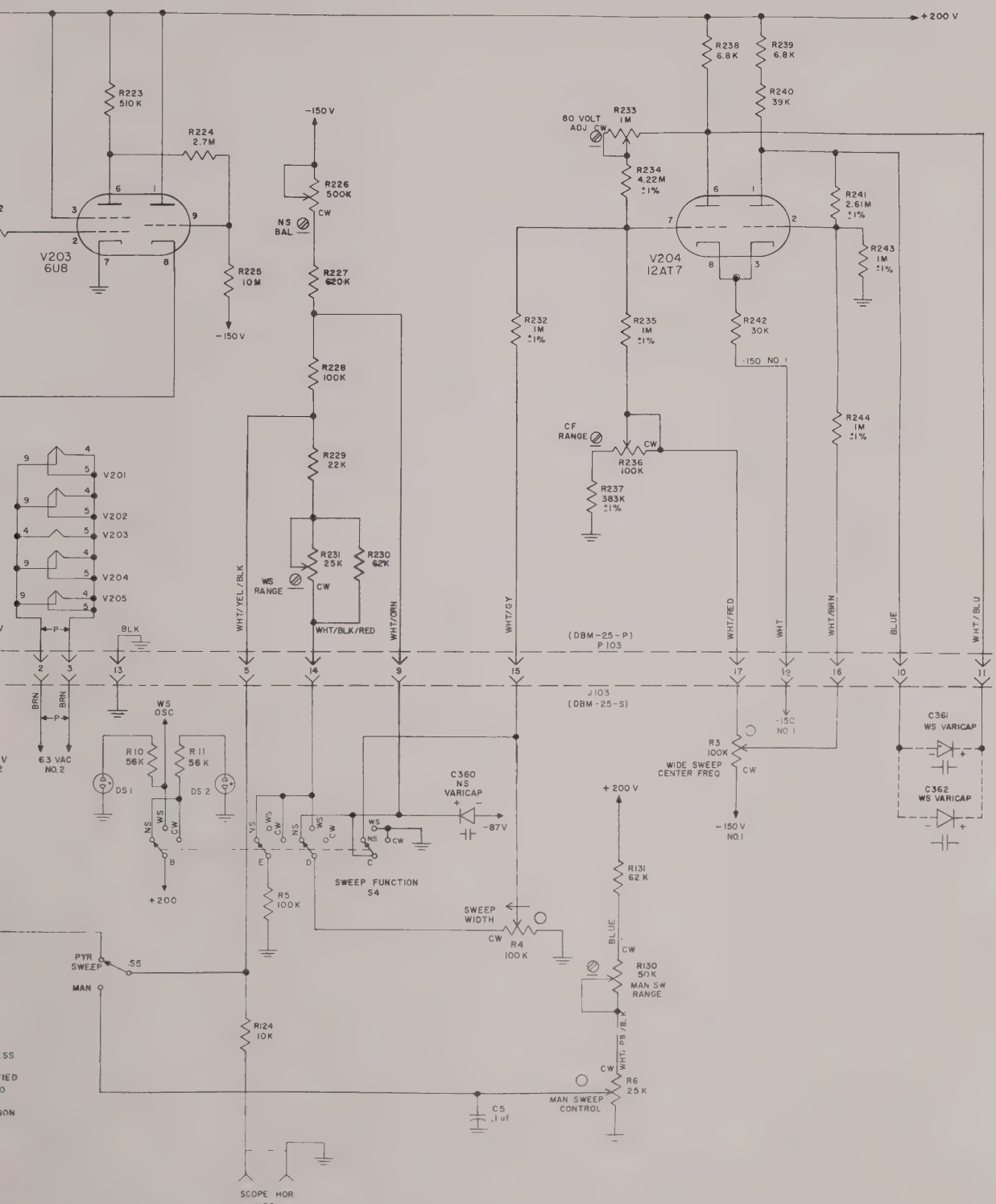
⊘ S.D. ADJUSTMENT (EXTERNAL)

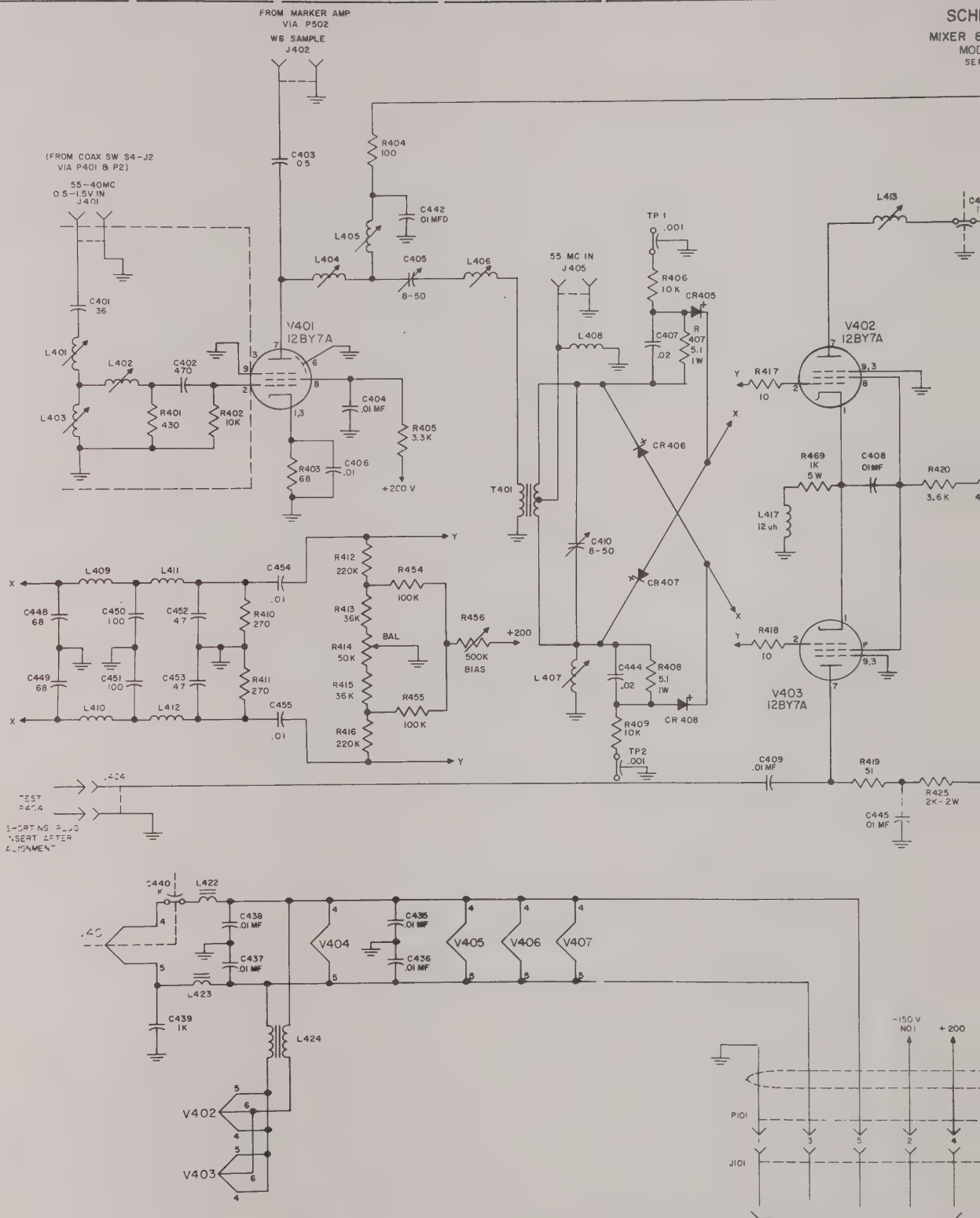
⊘ S.D. ADJUSTMENT (INTERNAL)





MATIC
VER UNIT
ERIES C



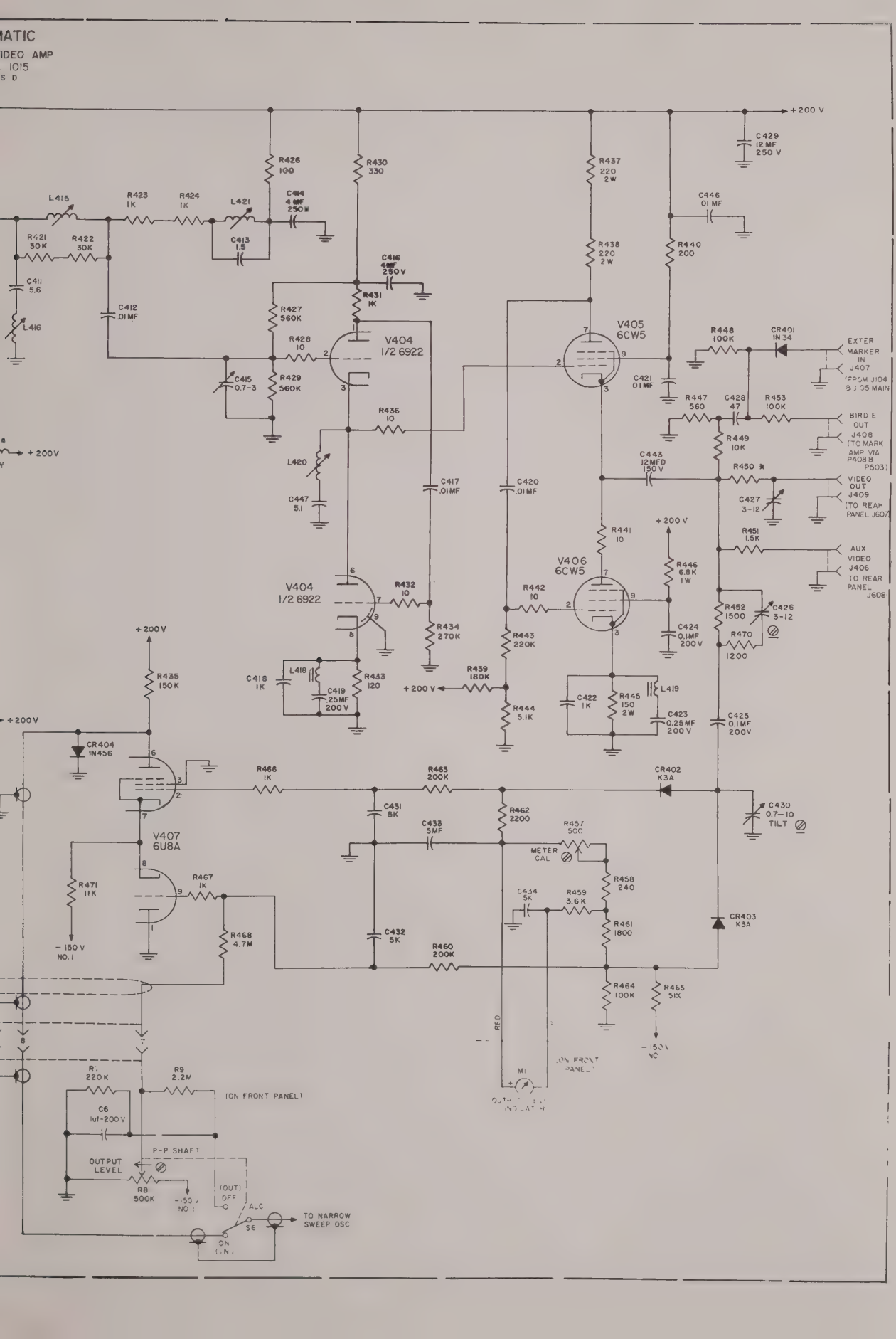


NOTES

1. ALL RESISTOR VALUES GIVEN IN OHMS, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES GIVEN IN PF, UNLESS OTHERWISE SPECIFIED.
3. ⫽ = INTERNAL ADJ

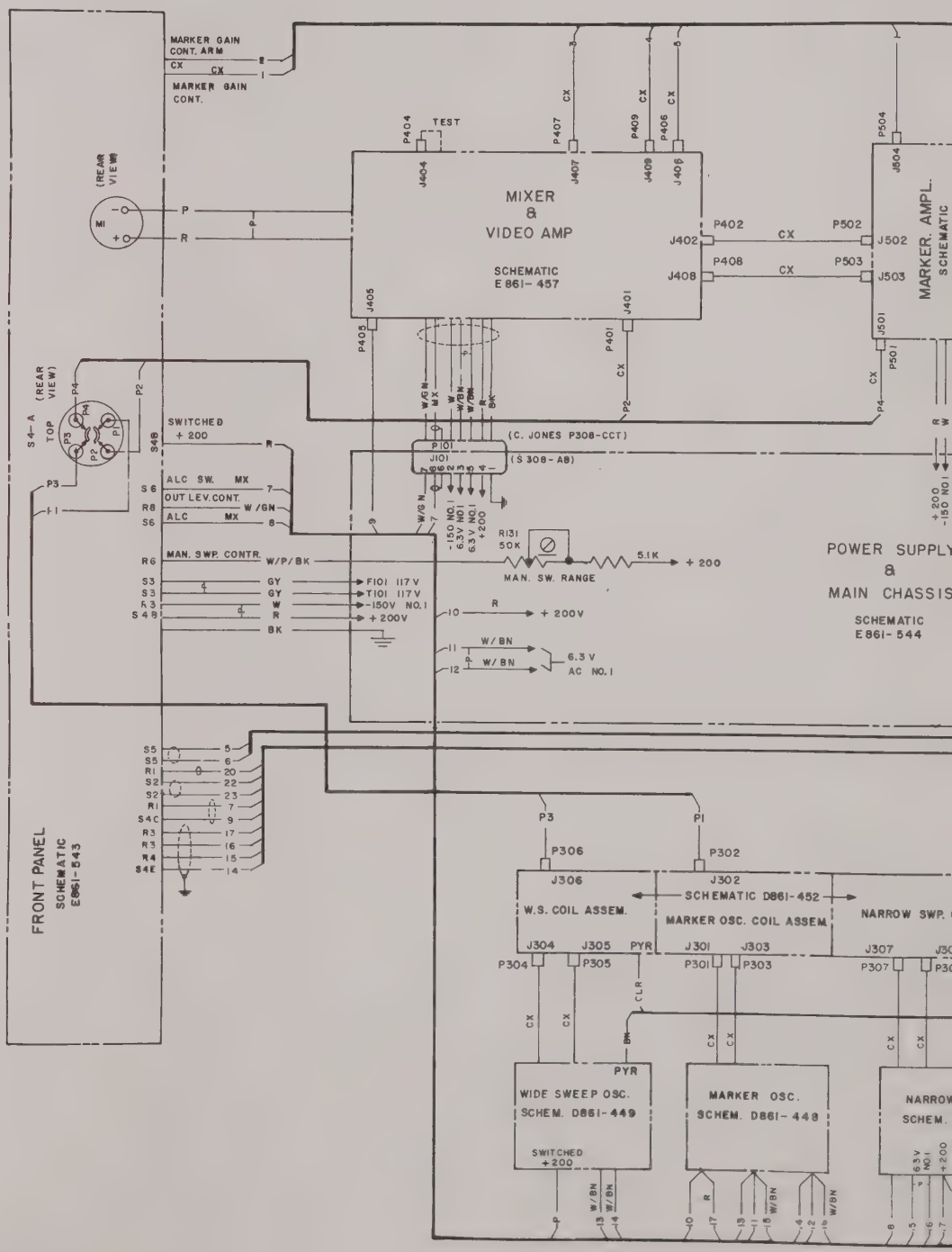
* 50 OHM MODEL — R450 — 50 OHM, 1/2 W, 1%
75 OHM MODEL — R450 — 75 OHM, 1/2 W, 1%

E861-762-0

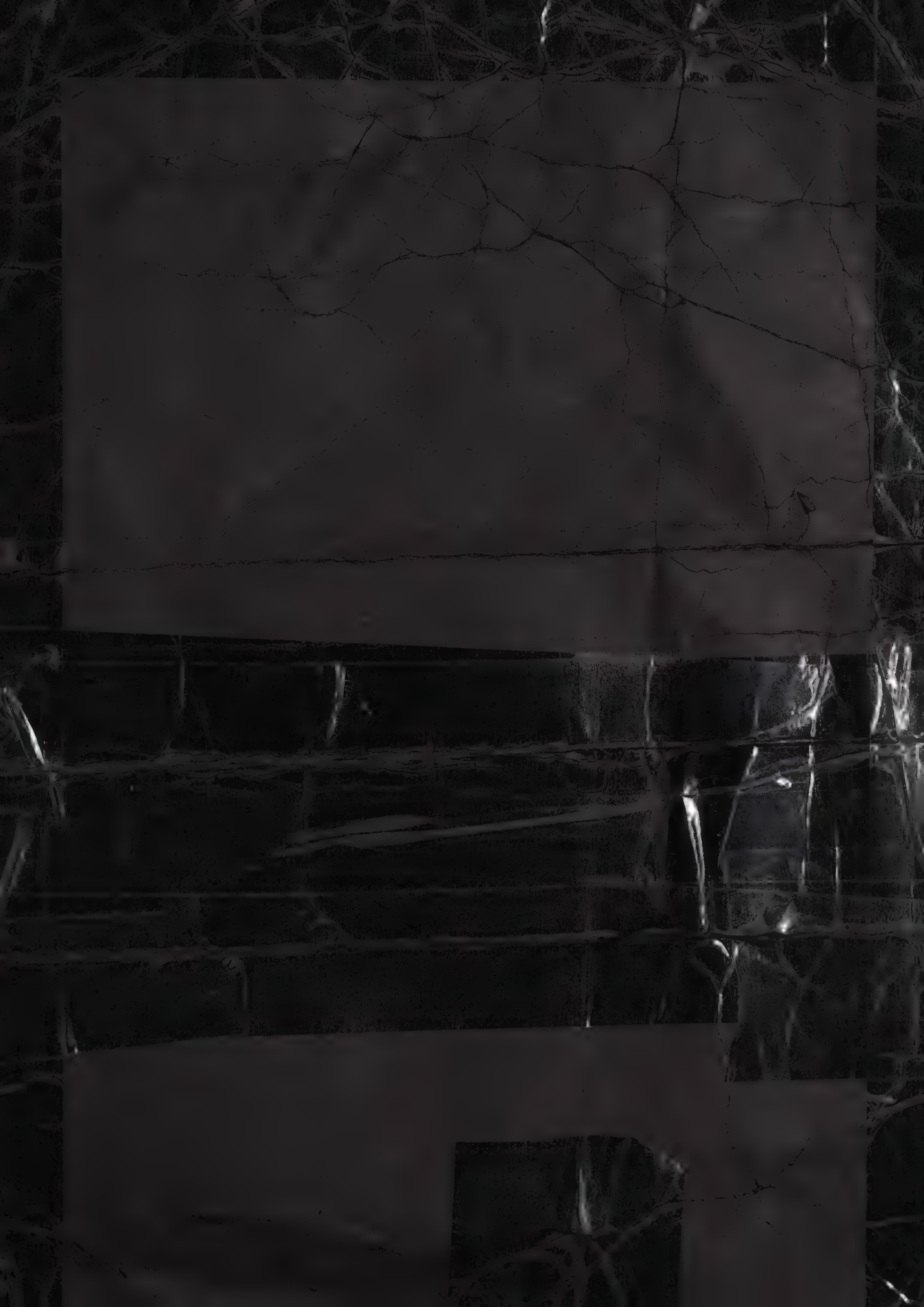

MATIC
IDEO AMP
1015
S D
+200 V
C429 12 MF 250 V
R426 100
R430 330
R437 220 2W
C446 01 MF
L415
R423 1K
R424 1K
L421
C414 250 V
R438 220 2W
R440 200
R421 30K
R422 30K
C413 1.5
C411 5.6
C412 .01 MF
L416
C416 250 V
R431 1K
R427 560K
R428 10
V404 1/2 6922
C415 0.7-3
R429 560K
V405 6CW5
R448 100K
CR401 IN 34
EXTER MARKER IN J407
C421 01 MF
R447 560
C428 47
R453 100K
BIRD E OUT J408 (TO MARK AMP VIA P408 & P503)
R449 10K
R436 10
C443 12MFD 150 V
R450
VIDEO OUT J409 (TO REAR PANEL J607)
L420
C447 5.1
C417 .01MF
C420 .01MF
C427 3-12
R441 10
+200 V
R451 1.5K
AUX VIDEO J406 TO REAR PANEL J608
V406 6CW5
R446 6.8K 1W
V404 1/2 6922
R442 10
R432 10
R452 1500
C426 3-12
R470 1200
R434 270K
R443 220K
C424 0.1MF 200V
+200 V
R435 150K
C418 1K
L418
R433 120
C419 .25MF 200V
R439 180K
+200 V
C422 1K
R445 150 2W
L419
C423 0.25MF 200V
C425 0.1MF 200V
R444 5.1K
+200 V
CR404 IN456
R466 1K
R463 200K
CR402 K3A
C430 0.7-10 TILT
C431 5K
C433 5MF
R462 2200
R457 500
METER CAL
V407 6U8A
R458 240
C434 5K
R459 3.6K
R471 11K
R467 1K
CR403 K3A
R461 1800
- 150 V NO. 1
R468 4.7M
C432 5K
R460 200K
R464 100K
R465 51K
- 150 V NO.
RED
M1
(ON FRONT PANEL)
R7 220K
R9 2.2M
(ON FRONT PANEL)
C6 1uf-200 V
P-P SHAFT
OUTPUT LEVEL
R8 500K
-150 V NO. 1
(OUT) OFF / ALC
S6
ON (IN)
TO NARROW SWEEP OSC

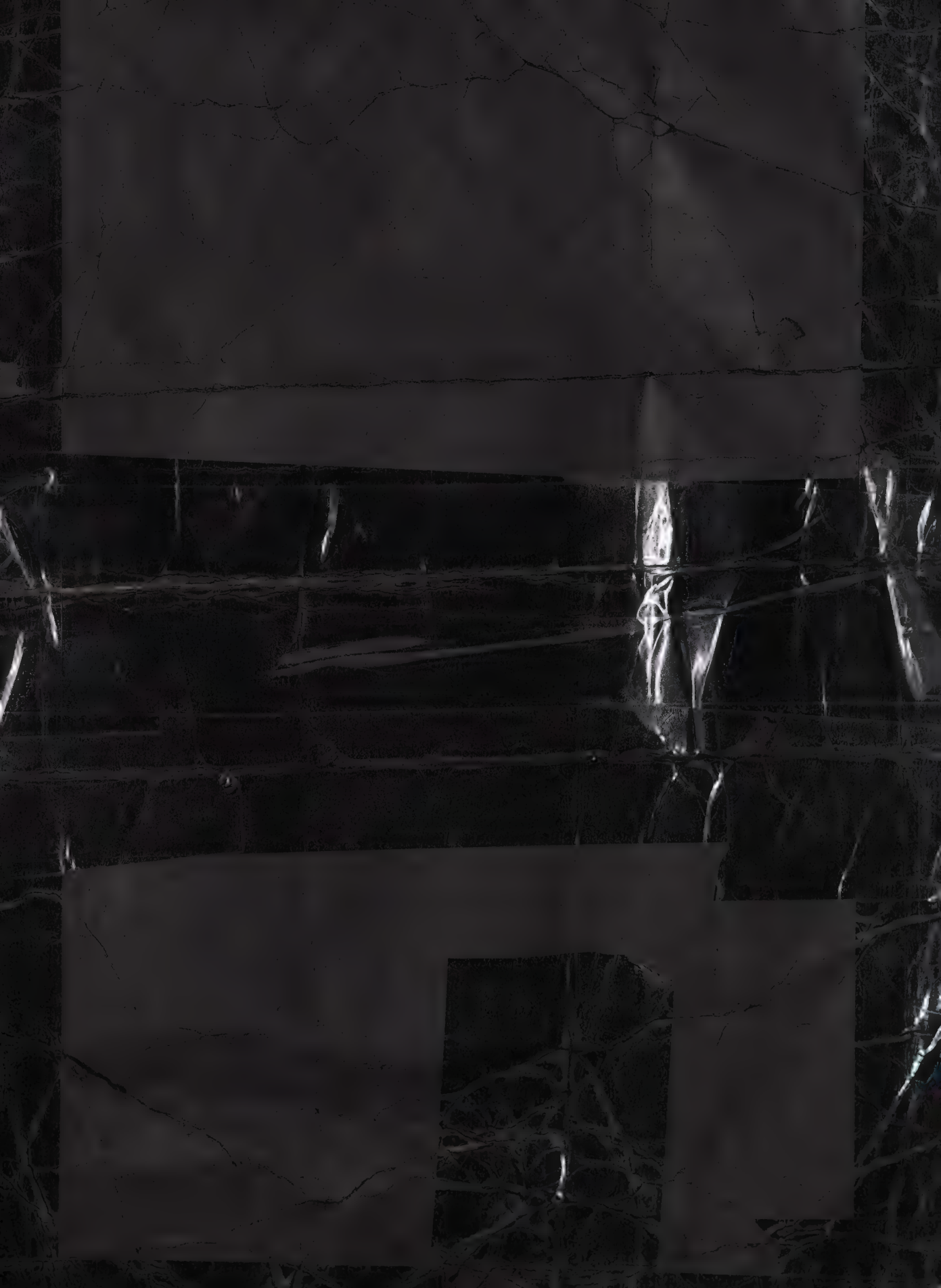
INTERCONNECTION

1015 SWEEP GENERA
SERIES C



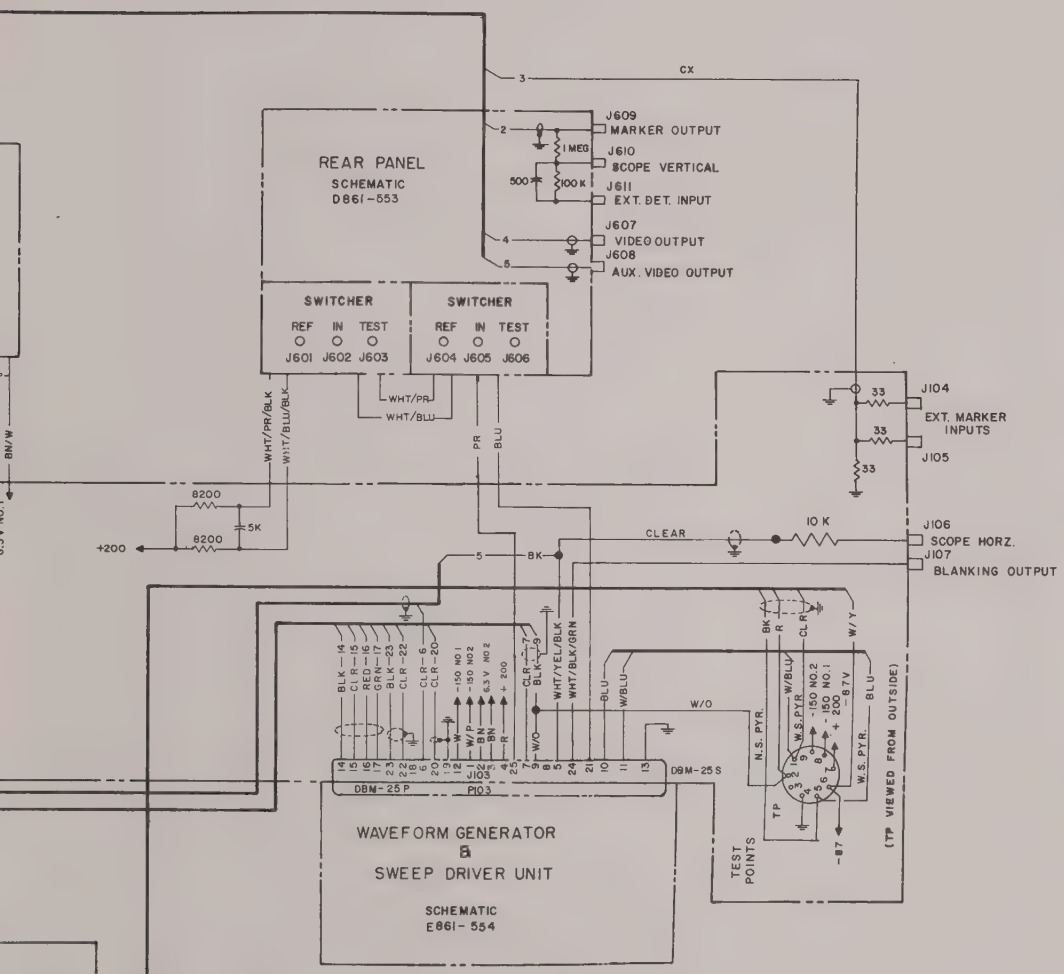
E862-040-0





DIAGRAM

TOR



NOTES:

1. CX = COAX RG-55/U
2. MX = MINIMAX 21-597
3. |-| = TWISTED PAIR
4. CXA = RG 55/U, 50Ω OUTPUT; RG 59/U, 75Ω OUTPUT.
5. WIRING CHANNELS ARE USED FOR CLARITY AND DO NOT NECESSARILY INDICATE CABLING.
6. NUMBERS OR WIRE COLOR CODE INDICATE CONTINUITY IN WIRING CHANNELS.

UNIT WIRING COLOR CODE

BK	GROUND	GN	GRIDS
R	+200, +400	Y	CATHODES
W	-150V NO 1	O	SCREEN GRIDS & INTERMED. B+
W/P	-150V NO 2	BLU	PLATES
W/BN	63 V AC NO 1	GY	POWER (117V AC)
BN	63 V AC NO. 2		

JERROLD

Technical Newsletter

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COMPARISON TECHNIQUE
IMPROVES SWEEP FREQUENCY MEASUREMENTS*

By K. A. SIMONS, Chief Engineer, Jerrold Electronics Corporation

The Jerrold Electronics Corporation maintains a Design Engineering Laboratory at Hatboro, Pennsylvania. The primary function of this organization is the design of electronic equipment, including wide-band amplifiers, filters and associated equipment in the "awkward" frequency range between 5 and 220 mc. This range is called awkward because the upper end is too high for measuring methods suitable for the low communications frequencies, and the lower end is too high for standing-wave line measurements. A number of measuring techniques, developed to meet this situation, are described in this article.

*A major part of this article appeared first under the title "SWEEP MEASUREMENTS MAKING THE TOUGH ONES EASY" in "electronics" Vol. 36, No. 16, April 19, 1963.

BASIC COMPARISON CIRCUIT

The basic technique is to compare transmission through two paths. Figure 1 shows the method used to determine accurately the transmission loss through a network. A test signal source and an output indicator are connected to a DPDT switch so that in one switch position (TEST) the signal is passed through the network the loss of which is to be measured, and in the other switch position (REFERENCE) it is connected through a variable calibrated attenuator.

To make a measurement, the operator throws the switch repeatedly back and forth, while adjusting the attenuator until the output indicator shows identical responses for both switch positions. The loss in the tested network is then equal to that of the attenuator and can be read off from its calibration.

This technique has been used for many years for precise transmission measurements in the telephone art. (See, for example, the article "Transmission Measuring for Manufacture," by George W. Pentico in THE WESTERN ELECTRIC ENGINEER, October, 1961.)

The technique has some of the basic advantages of the more familiar null-bridge measuring method, namely:

1. High source output and a sensitive indicator make very precise settings possible.
2. Other characteristics of the source and indicator have little effect on the accuracy of the result. Neither needs to be calibrated, and the amplitude stability need only be constant long enough for a comparison to be made.
3. Calibration accuracy is entirely determined by a convenient passive attenuator.

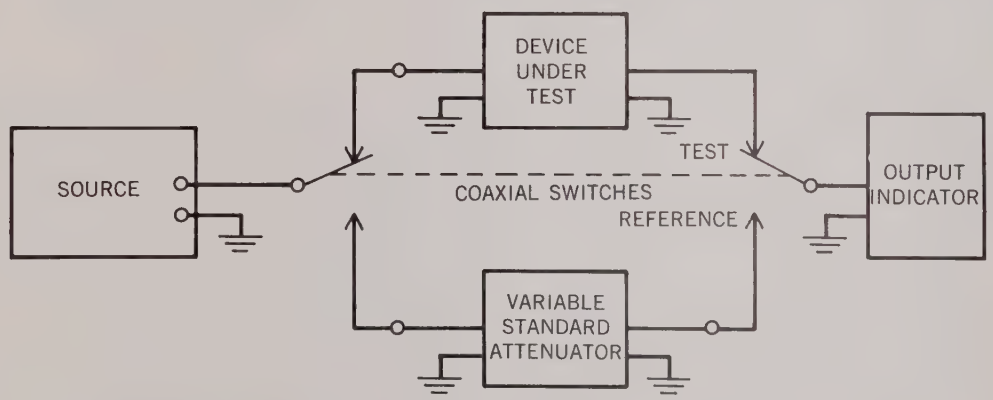


Fig. 1

COMPARISON WITH SWEEP DISPLAY

This approach is a "natural" for sweep frequency testing over wide frequency bands. Sweep frequency generators and oscilloscopes are notoriously as poor on calibration as they are good on sensitivity, while stable and accurate attenuators are common. To adapt to the sweep situation, the basic technique is modified in two respects:

1. High frequency measurements necessarily involve coaxial transmission lines; thus the comparison switch, as part of the transmission system, must be coaxial with an impedance matching that of the associated lines.

2. Oscilloscopic display of a sweep frequency response curve requires periodic repetition of the measurement (usually 60 times per second) so the eye can see a steady pattern. The "switch" must also operate period-

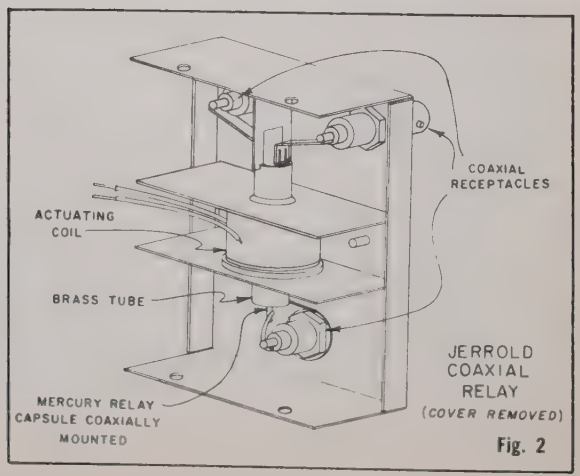


Fig. 2

ically so that the calibration may be seen as part of this stationary pattern. To achieve periodic switch operation, a high speed coaxial relay is used. The construction is illustrated in Figure 2. A Clare mercury-wetted relay capsule is mounted so that it forms a well-matched coaxial structure. This unit operates at high speeds (up to 60 cps) with no bounce and with very long life.

Switches have been in full-time operation in our laboratory for five years with negligible failures.

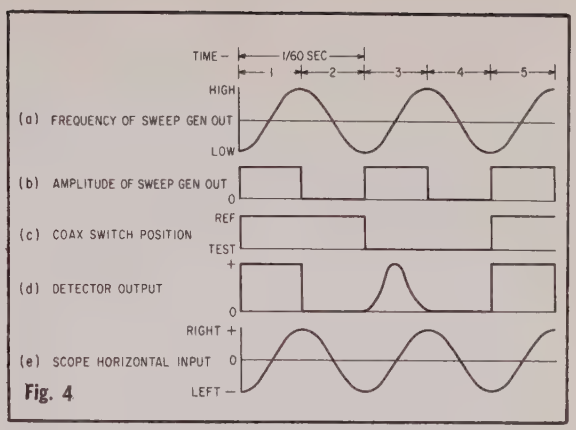


Fig. 4

MEASURING LOSS BY COMPARISON

The test set-up for measuring and displaying the high frequency loss of a network by the sweep-frequency comparison method is diagrammed in Figure 3. The output of a Sweep Frequency Generator, sweeping across the desired band at a 60-cycle rate, is connected to one of two SPDT coaxial switches. The other switch is connected to the input of a wide-band detector. The switches transmit alternately through the network under test and through the variable attenuator.

When this detector output is applied to an oscilloscope's vertical input terminals, and a voltage, with its instantaneous magnitude phased to match the instantaneous frequency of the generator, is applied to the horizontal output terminals, the scope traces out the display illustrated in Figure 4f. (In the example shown, the horizontal deflecting voltage must be a 60-cycle sine-wave phased as shown, to agree with the waveform and phase of the frequency modulation.)

The curve presents the loss as it varies with frequency in the unit under test, together with a base line showing zero response (infinite loss) and the REFERENCE trace showing the loss corresponding to the attenuator setting.

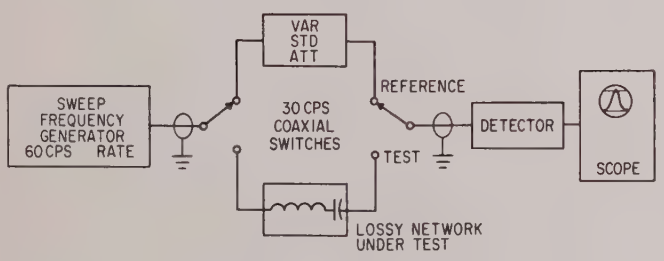


Fig. 3

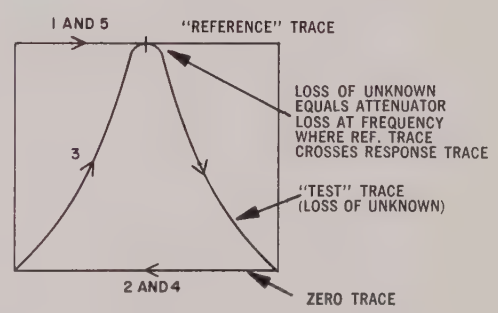

1 AND 5
"REFERENCE" TRACE
LOSS OF UNKNOWN EQUALS ATTENUATOR LOSS AT FREQUENCY WHERE REF. TRACE CROSSES RESPONSE TRACE
3
"TEST" TRACE (LOSS OF UNKNOWN)
2 AND 4
ZERO TRACE
Fig. 4f

Figure 4 illustrates the manner in which the display is generated. The frequency of the sweep output varies sinusoidally between an upper and a lower limit (Figure 4a) at a 60-cycle rate. The output is cut off during the return trace (Figure 4b) to form a zero reference trace. The coaxial switches are transferred at a 30-cycle rate (Figure 4c) allowing the development of a full trace in the REFERENCE position followed by a full trace in the TEST position. As a result, the detector output (Figure 4d) goes through four conditions in each thirtieth of a second; first indicating reference output, second delivering zero output, third following the loss curve of the unit under test and fourth repeating the zero output trace.

The REFERENCE trace crosses the TEST trace at those frequencies where the loss of the unit under test precisely equals the loss of the standard attenuator.

The scope trace photograph in Figure 5 shows the insertion loss measurement of a triple-tuned band-pass filter. The attenuator was set at 1.0 db and the point at which the REFERENCE trace crosses the response shows a loss of 1.0 db at a 7-mc band-width centered on 125 mc. It is a major advantage of this presentation that the accuracy of the measurement is not affected by the constancy of the sweep output across the band, the flatness of the detector, or by drift or other changes in scope gain and centering.

In cases where very small attenuation differences are to be observed, it is convenient to increase the vertical gain and recenter the trace to show a highly expanded view of part of a response pattern. This is illustrated in the series beginning with Figure 6. A Jerrold 900-B sweep frequency generator was set to sweep between zero and 200 mc, and a short coaxial jumper was connected between its output and a detector. The scope vertical gain was increased to about four times that required to show the change from zero to full output, and the centering readjusted to bring the resulting trace onto the screen.

Under this condition the screen showed a change of only 0.2 db per division and the resulting trace (Figure 6) shows the sweep output to be constant within ± 0.2 db. With the same sweep and scope settings, the sweep output was then connected through two coaxial switches (Jerrold Model FD-30) transferring between a short jumper and a variable attenuator (Jerrold Model AV-50) connected through two 2-foot coaxial cables.

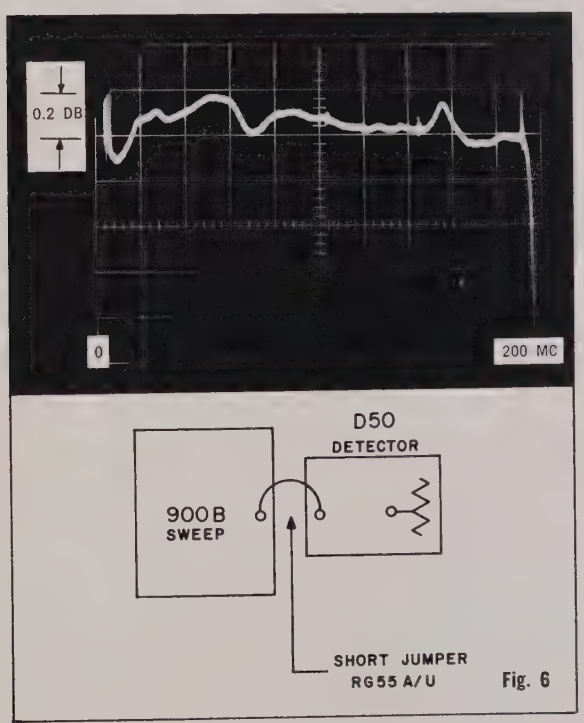
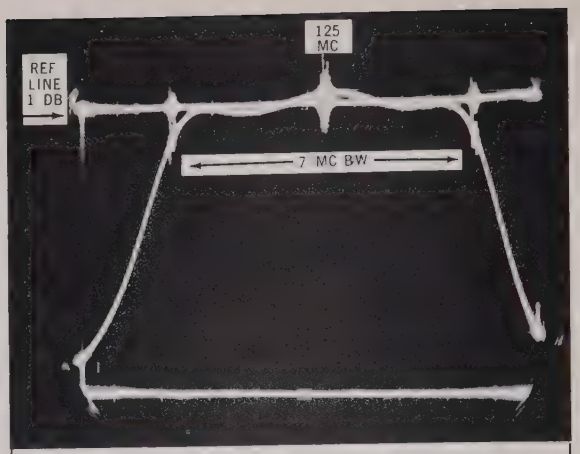


Fig. 6



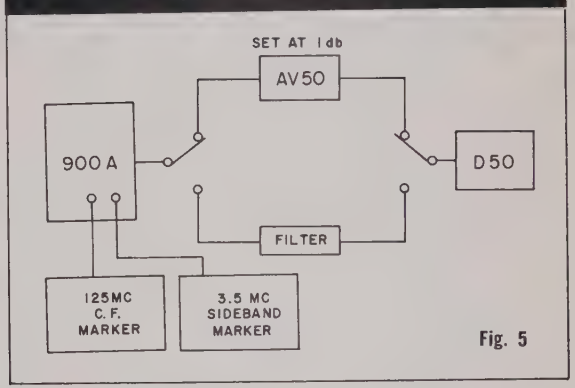
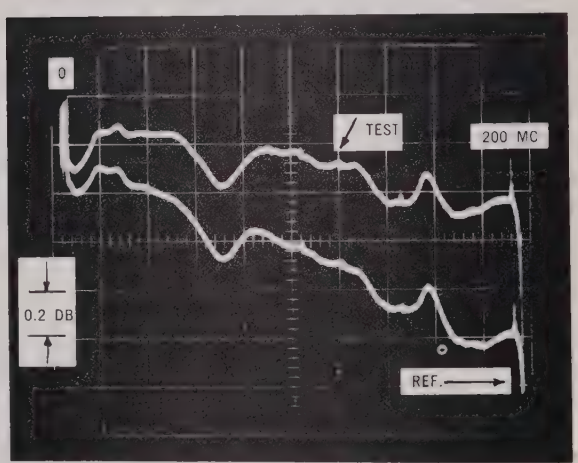


Fig. 5



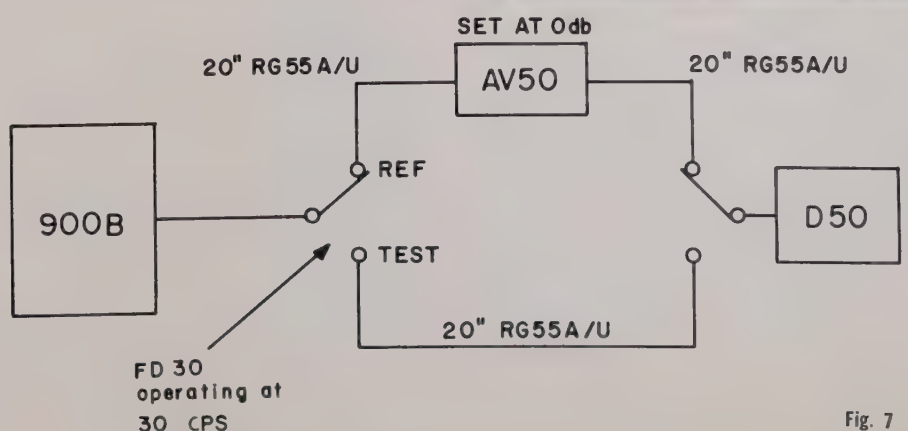


Fig. 7

The resulting photograph (Figure 7) compares the jumper loss with the attenuator insertion loss (at zero setting) continuing with the same expanded vertical scale. By careful inspection it can be seen that the TEST (upper) trace is slightly down at the high end (compared with Figure 6) indicating that the coaxial switches and short jumper have added about 0.2 db loss at 200 mc, while the REFERENCE (lower) trace shows that the attenuator and its longer cables have added about 0.8 db loss at the high end.

If precise measurements are to be made it is **not** essential that either curve be precisely flat, but it **is** essential that the loss on the TEST side, before inserting the unknown, be the same as that on the REFERENCE side. This condition was satisfied by inserting additional cable on the TEST side (totalling 137 inches) so that the insertion losses in both circuits were close to identical. The resulting trace was photographed (Figure 8a) and shows considerably less than 0.05 db difference between the two circuits over the whole frequency range from low frequencies up to 200 mc. Inserting an additional 0.5 db into the standard attenuator gave the result illustrated in Figure 8b, showing that this set-up could be used for loss measurements involving very small attenuation differences.

Figure 9 shows how this approach was applied to a practical measuring problem. We wanted to test a repeater amplifier designed for long cascaded runs in television distribution systems. The amplifier, together with its equalizer, is required to have gain equalizing as closely as possible the loss of 2000 feet of a particular coaxial cable between the frequencies of 5 and 95 mc. To test this, the cable, the equalizers and the amplifier were connected, each following the other on the TEST side of the comparison circuit, with a jumper providing a zero loss reference on the REFERENCE side. The resulting response (illustrated in Figure 9b) shows that the combination of cable plus equalizer plus amplifier had zero loss within about $\pm$ 0.25 db between 5 and 95 mc. The fine grained ripple is primarily due to variations in the cable's transmission characteristic.

The usefulness of this technique is obvious, first in the fact that it would take many hours to make this measurement using point-by-point techniques and even then the accuracy would be questionable, and second in the fact that the necessary refined adjustments of the equalizer and amplifier can be carried out quickly and accurately while observing the display, which could not be done with a point-by-point approach.

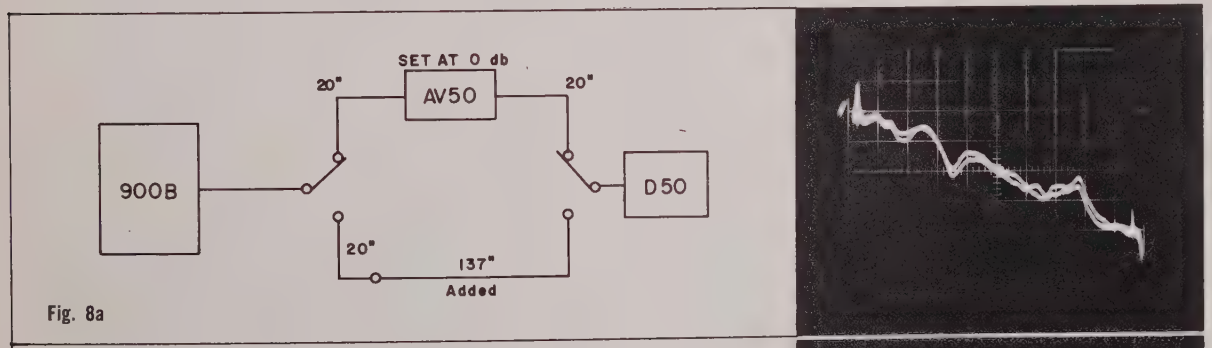


Fig. 8a

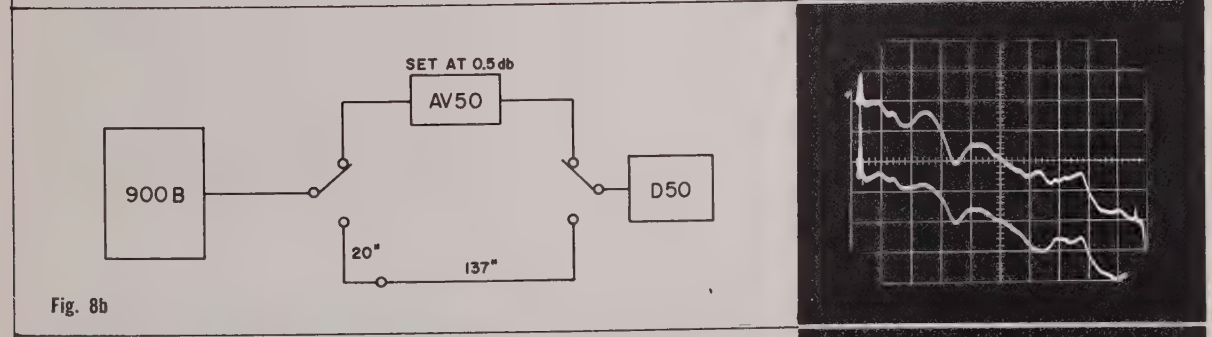


Fig. 8b

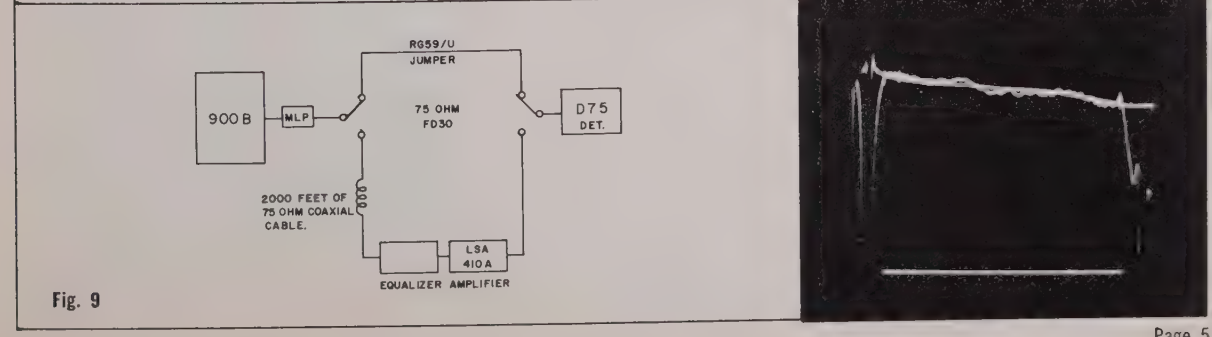


Fig. 9

MEASURING GAIN BY COMPARISON

The comparison technique can be used effectively for the measurement of amplifier gain. The basic circuit is diagrammed in Figure 10. By using a jumper as a zero loss reference and inserting the variable attenuator ahead of the amplifier on the TEST side, the REFERENCE line is made to cross the amplifier response curve at the point where the attenuator loss equals the amplifier gain. The resulting display is illustrated in Figure 11.

The photographs in Figure 12 illustrate gain measurement on an amplifier designed to pass television channel 13 for use in rf distribution systems. Figure 12a illustrates the response curve in the TEST position with a frequency marker at band center (213 mc). Figure 12b illustrates a useful frequency marking technique where a low frequency generator (3 mc) is connected simultaneously with a high frequency one and the resulting side-bands mark the channel edges (213 ± 3 mc). Figure 12c illustrates the trace with the coaxial switch running and the attenuator set at 57 db (0.5 db below the maximum amplifier gain).

To obtain a "blown-up" view of the pass band response, the scope gain was turned up and the trace recentered to give the result shown in Figure 12d. This shows that the amplifier response is within 0.1 db across the band. Neither the measurement, nor the alignment which preceded it, could be readily carried out by any single frequency measurement technique.

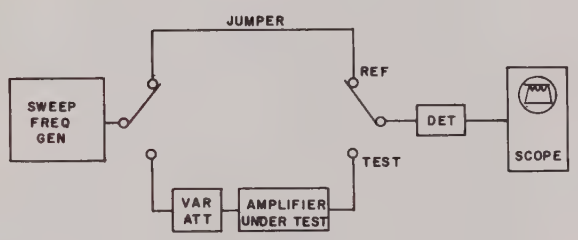


Fig. 10

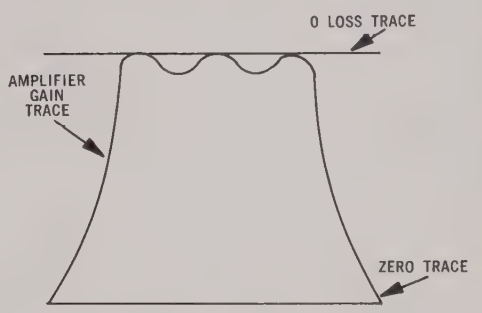
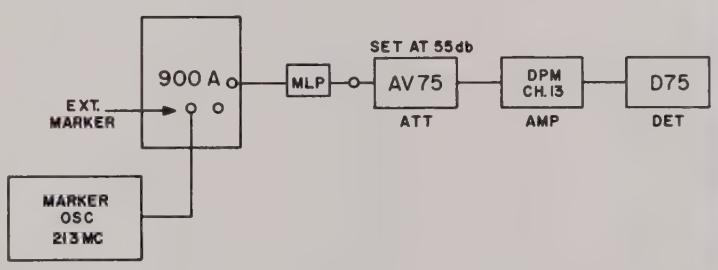


Fig. 11



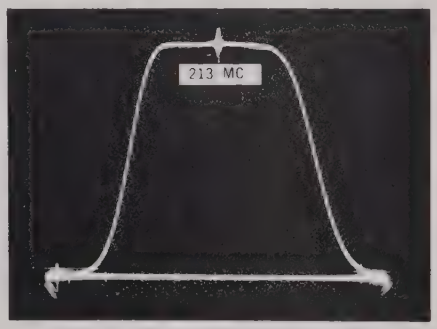
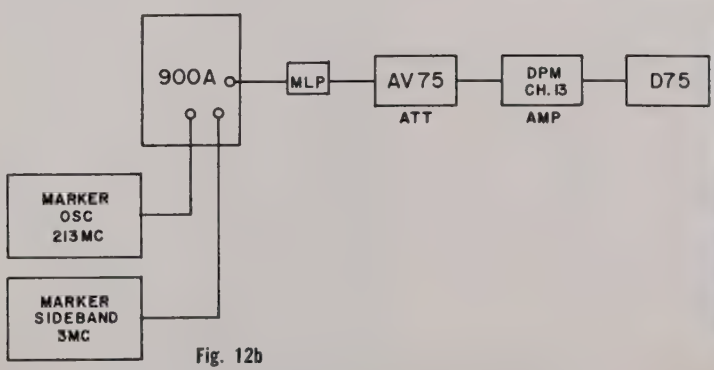


Fig. 12a



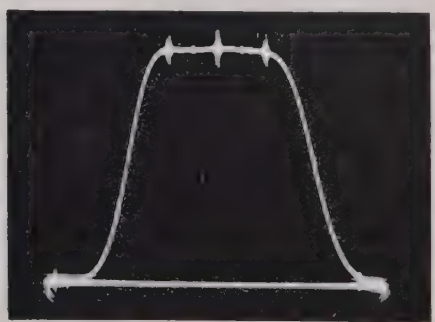


Fig. 12b

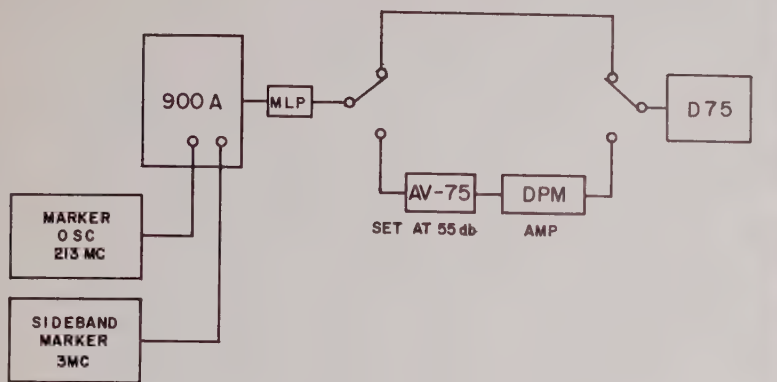
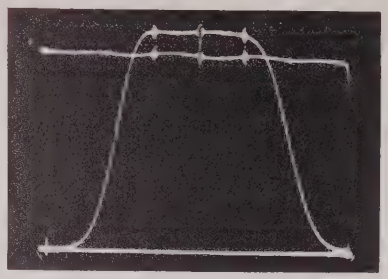


Fig. 12c



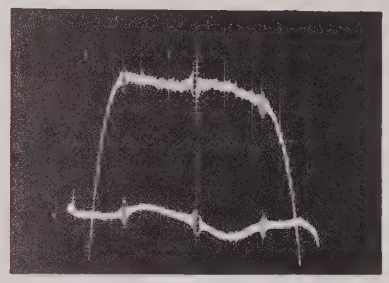


Fig. 12d

MEASURING IMPEDANCE MATCH BY COMPARISON

In addition to gain and loss measurements, a third application of the comparison method was found to be very useful in our laboratory. This involves employing a bridge circuit to provide wide-band display of impedance match characteristics. As described more fully in TNL, Vol. 1, No. 4, the technique depends on the characteristics of a high frequency bridge having six equal arms (including the impedance of the source and detector). The bridge circuit is diagrammed in Figure 13 and its effect is summarized by the fact that the insertion loss between the input and output terminals is equal to 12 db plus the return loss of that which is connected to the unknown terminal (return loss is the ratio of the reflected wave in a coaxial system to the incident wave, expressed in db). Stating this another way: when a signal is introduced into the input terminal of the bridge, the output signal is the reflected wave from the unknown diminished by 12 db.

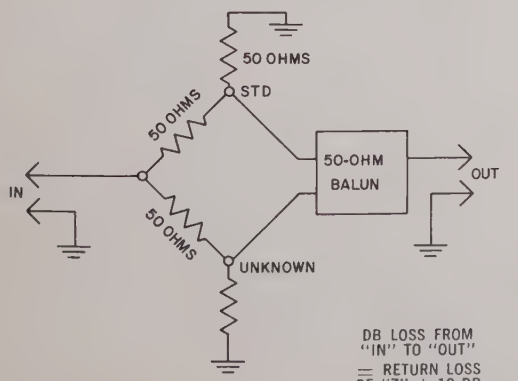


Fig. 13

Thus the bridge makes possible impedance measurements over a wide frequency band, converting impedance variations into loss variations which are then accurately measured by the comparison technique. It is, in effect, a directional coupler giving flat response over a very wide band of frequencies in the "awkward" 5 to 200 mc range. The equipment set-up for impedance sweeping is diagrammed in Figure 14. The bridge is connected to the TEST terminals of the comparison switches and a fixed 12 db attenuator is connected with the standard attenuator in the REFERENCE leg. To obtain adequate gain for the measurement of small reflections, a wide-band distributed amplifier is connected ahead of the detector. The display obtained is shown in Figure 14b, the REFERENCE trace crossing the unknown at a return loss level corresponding to the attenuator setting. The bridge we are now using allows measurement of return loss in the range 0 to 40 db, with an accuracy within $\pm$ 1 db.

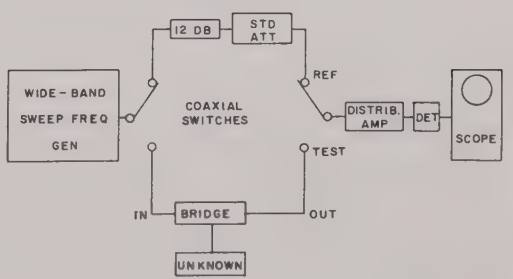


Fig. 14a

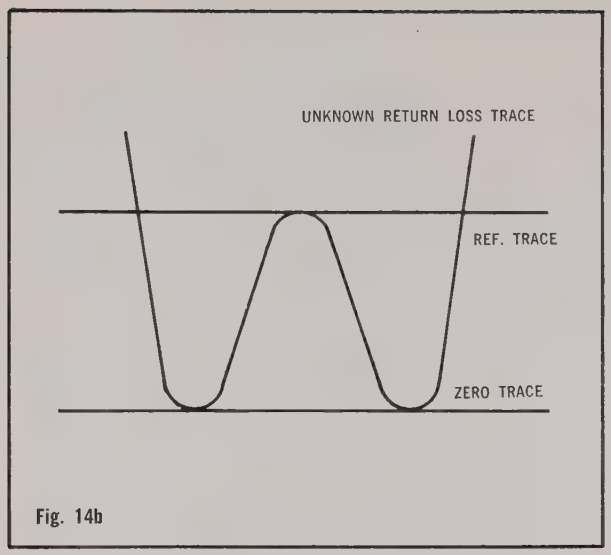


Fig. 14b

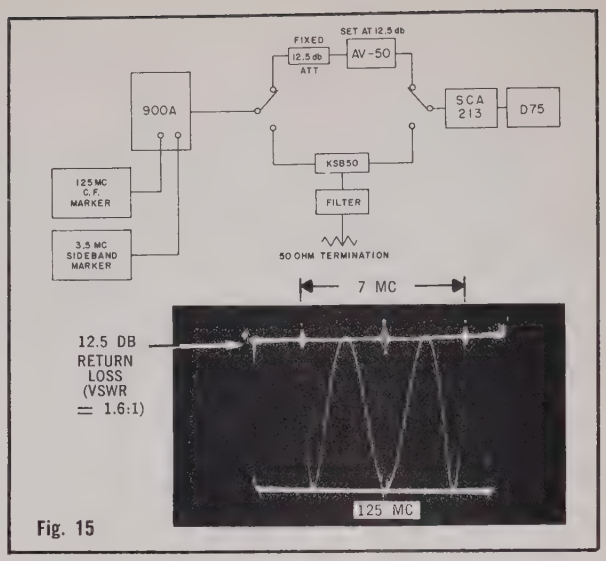


Fig. 15

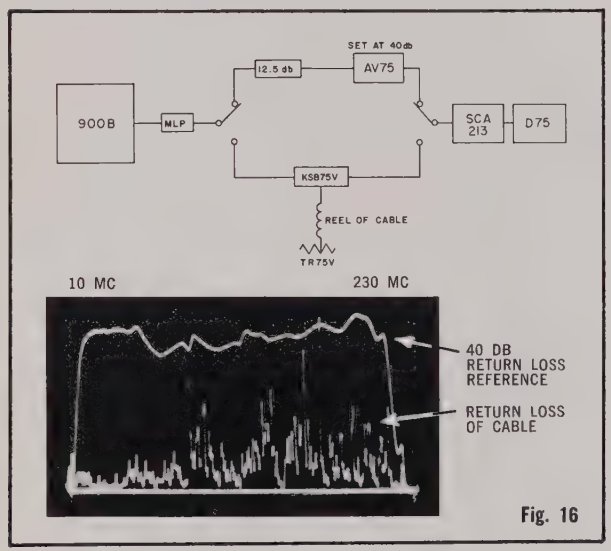


Fig. 16

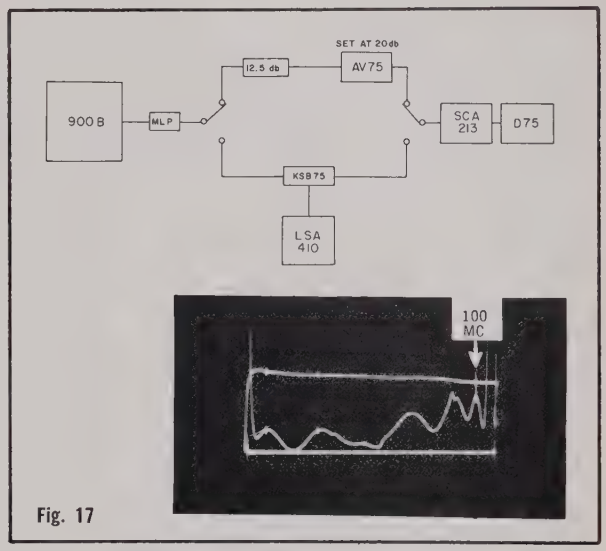


Fig. 17

Figure 15 illustrates measurement of the input impedance of the band-pass filter the insertion loss of which is shown in Figure 5. The filter was aligned for maximum return loss of 12.5 db (max. VSWR of 1.6:1) with Chebishev (equal ripple) match characteristics. Adjustment and measurement were carried out rapidly with the aid of the comparison presentation.

Figure 16 illustrates measurement of the "structural return loss" (the impedance variations due to minor mechanical irregularities) in a 1000-ft. piece of unusually good coaxial cable. The maximum reflection spike at about 150 mc had a return loss level just over 40 db.

Measurement of such a complex characteristic over this frequency range would be a maddening (if not impossible) process by any point-by-point technique.

Figure 17 illustrates the impedance match at the output terminal of the amplifier the response of which was shown in Figure 9. Without the rapid and accurate measurement of match made possible by the return loss bridge, production alignment of this amplifier to meet the required overall performance would be impossible.

CONCLUSION

The comparison technique has been described as it is used at the Jerrold Laboratory for measurement of loss, gain, and impedance match, simultaneously with sweep frequency display of these characteristics. This technique has been found absolutely indispensable in the speed and convenience it contributes to the design and adjustment of a variety of devices in the "awkward" frequency range between 5 and 220 mc.

NOTE — Additional copies of this paper and engineering assistance on the application of Measurements By Comparison may be obtained by contacting the Industrial Products Division, Jerrold Electronics Corporation, 15th & Lehigh, Phila., Pa. 19132. Phone: BAldwin 6-3456 — Ext. 215.

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NEW ATTENUATOR AND COMPARATOR

EXTEND FREQUENCY RANGE OF COMPARISON TECHNIQUE TO 1200 MC.

Fig. 2—Model ATV-109R
Rack-Mounting Bank
of Turret Attenuators

Fig. 1—Model TC-3
Coaxial Comparator

SUMMARY: A new drum attenuator and a transistorized three-way coaxial comparator are described, which allow accurate sweep-frequency measurements of transmission loss, gain, and reflection coefficient in 50-ohm coaxial systems from DC to 1200 MC.

INTRODUCTION

For the past six years, Jerrold has been offering as accessories to the 900-A and 900-B Sweep-Frequency Generators a comparator (high speed coaxial switch Model FD-30) and variable attenuators (Model AV-50). When used with a wide-band sweep-frequency generator these allow quite accurate measurements of transmission gain and loss[1], and when used with a suitable bridge, measurement of reflection coefficient (return loss)[2] to a limit of accuracy determined by the characteristics of these accessories. The FD-30 Comparator and the AV-50 Attenuator were originally designed for use in the frequency-range up to 250 MC, where they had excellent characteristics, with reasonably good performance up to 500 MC. Since the Model 900 Sweep Generators provide coverage up to 1200 MC there has been a need for improved accessories, making the comparison technique available up to the limit of the sweep capability.

The new Model TC-3 Transistorized Comparator and the Model ATV Turret Attenuators have been developed to meet this need. They provide measurement accuracy up to 1200 MC, somewhat better than that obtained with the older equipment up to 250 MC, and in addition feature several marked improvements in operating convenience over the older equipment.

1. Jerrold Technical Newsletter Volume 2, Number 1—March 1964. COMPARISON TECHNIQUE IMPROVES SWEEP FREQUENCY MEASUREMENTS. Ken Simons, Jerrold Electronics Corporation.

2. Jerrold Technical Newsletter Volume 1, Number 4—August 1960. A BRIDGE METHOD OF SWEEP FREQUENCY IMPEDANCE MEASUREMENT. (Same author.)

MODEL TC-3 COAXIAL COMPARATOR

Figure 1 shows the Model TC-3 Coaxial Comparator. It consists of two basic housings arranged so that they can be mounted one on top of the other to form a convenient package for bench-mounting, or mounted side-by-side to form a 3½" high panel in a standard 19" rack. One of the units houses the transistor driver and the controls; the other houses the two coaxial switch assemblies. Each switch assembly consists of three reed relays mounted to form a single-pole triple-throw coaxial switch.

At frequencies in the gigacycle region, jumper cables present a major limitation on the accuracy of measurements. Therefore, accuracy is greatly improved if jumper lengths are kept to an absolute minimum. For this reason each assembly switch has been designed so that it can be removed from the housing and extended on a long cable so that it can be placed immediately adjacent to the units being tested. The reed relays operate equally well in any position; thus the switching heads can be positioned to suit the physical position of the units under test.

The operation of the new comparator can best be explained by comparing it with the FD-30. Figure 3a illustrates application of the FD-30 to the measurement and display of the frequency response of a resonant network. The sequence of operations when the unit is used with a 60-cycle supply is illustrated in Figure 3b and the resulting scope trace is shown in Figure 3c. Note that the complete cycle occurs in one-thirtieth of a second, and that the zero line is traced out twice in each cycle.

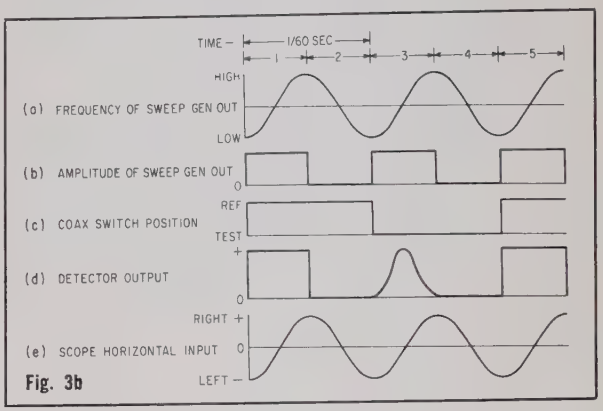


Fig. 3b

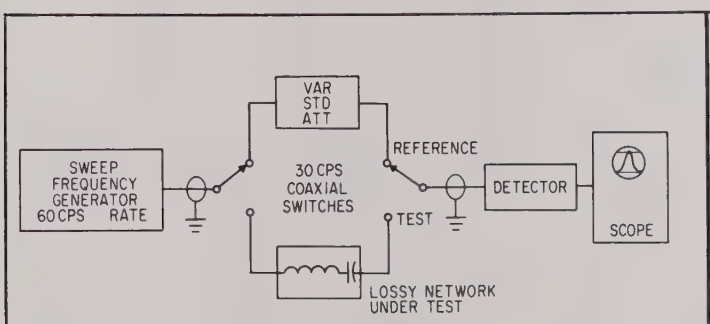


Fig. 3a—Operation of 2-Way Comparator Model FD-30

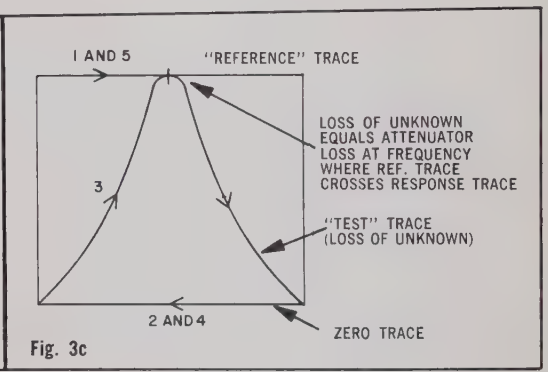

1 AND 5
"REFERENCE" TRACE
LOSS OF UNKNOWN EQUALS ATTENUATOR LOSS AT FREQUENCY WHERE REF. TRACE CROSSES RESPONSE TRACE
3
"TEST" TRACE (LOSS OF UNKNOWN)
2 AND 4
ZERO TRACE
Fig. 3c

Figure 4a illustrates the application of the three-way comparator using two attenuators to show simultaneously the maximum response and the 3 db down point of a resonant circuit on an oscilloscope. Figure 4b diagrams the sequence of operations. Note that the switches "A" close during the first quarter cycle, connecting attenuator "A" into the circuit; switches "B" close during the next quarter cycle connecting attenuator "B" into the circuit; during the third quarter cycle, switches "C" close, connecting the unknown; and all switches are open during the fourth quarter cycle, producing the zero base line. The resulting scope trace is shown in Figure 4e. The response curve is displayed with a zero base line and two reference lines. The position of the reference lines on the trace corresponds to the attenuation of two separate attenuators.

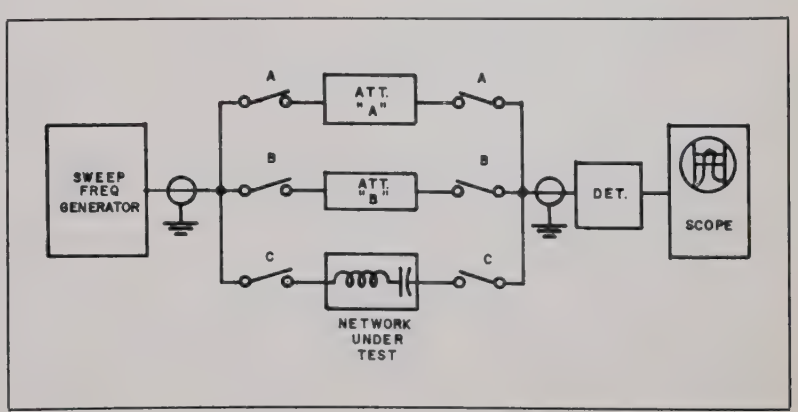


Fig. 4a
Operation of
3-Way Comparator
Model TC-3

This three-way display allows, for example, setting up a production test position with high and low limits of gain, loss, or impedance, keyed into the scope so that all calibrations are independent of generator output or scope drift.

Figure 5 shows a block diagram of the transistor driver employed to obtain this operation. With the input switch in INT position, the synchronizing input is obtained from a 60-cycle AC connection to the power supply through a 360° phase shifter. With the switch on EXT, an external synchronizing input may be used at any frequency between zero and several hundred cycles. A source capable of supplying six volts peak-to-peak into 20,000 ohms is required. Regardless of the input wave form, the switches will operate about one millisecond after each zero volt cross-over.

The internal or external synchronizing signal is shaped by a Schmitt trigger and clipper and the resulting square wave, which has the same frequency as the synchronizing source, is applied to a two-to-one counter generating a square wave at ½ that frequency. Both square wave voltages are applied to a diode AND gate, which controls the input to three driver transistors so that these are keyed in the sequence required to drive the relay coils. A function switch selects one of three switching mode connections to the driver transistors so that relay switching can be performed either: manually, or by three-way automatic switching, or by two-way automatic switching giving operation similar to the FD-30.

Three reed relays are used in each of two heads, mounted coaxially to obtain the best possible impedance match up to 1200 MC. The impedance match, when the switch is terminated in a precise 50 ohms, is held to a close tolerance as shown by the characteristic in Figure 6. The relay units were selected to give an unusually high degree of isolation when open, and low insertion loss when closed. The insertion loss, when the switch is closed, is less than 0.1 db from DC to 1200 MC. When open, the capacity is less than 0.085 pf giving an insertion loss which decreases with frequency, as shown in Figure 7.

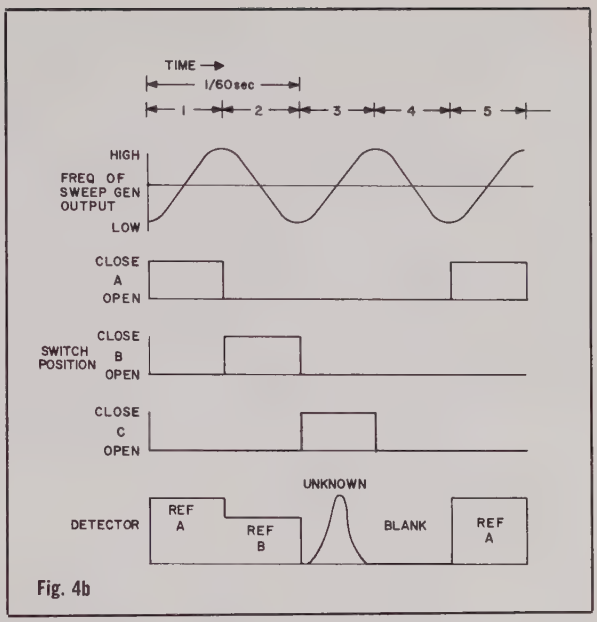


Fig. 4b

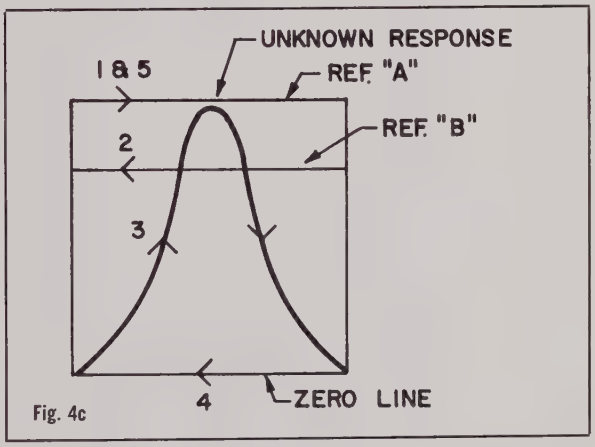


Fig. 4c

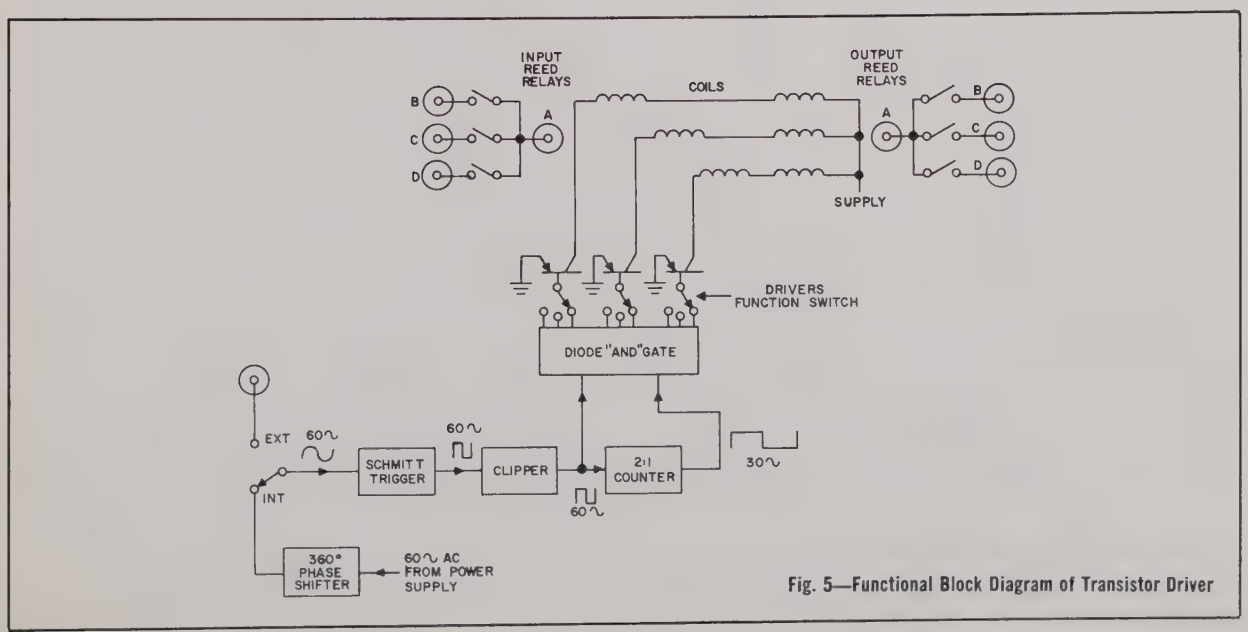


Fig. 5—Functional Block Diagram of Transistor Driver

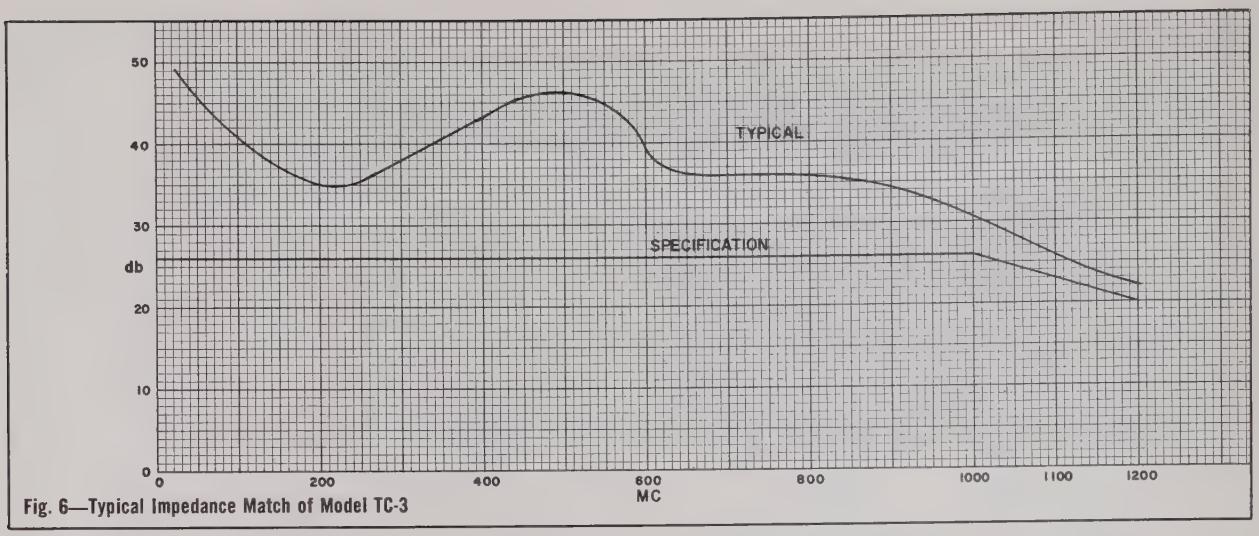


Fig. 6—Typical Impedance Match of Model TC-3

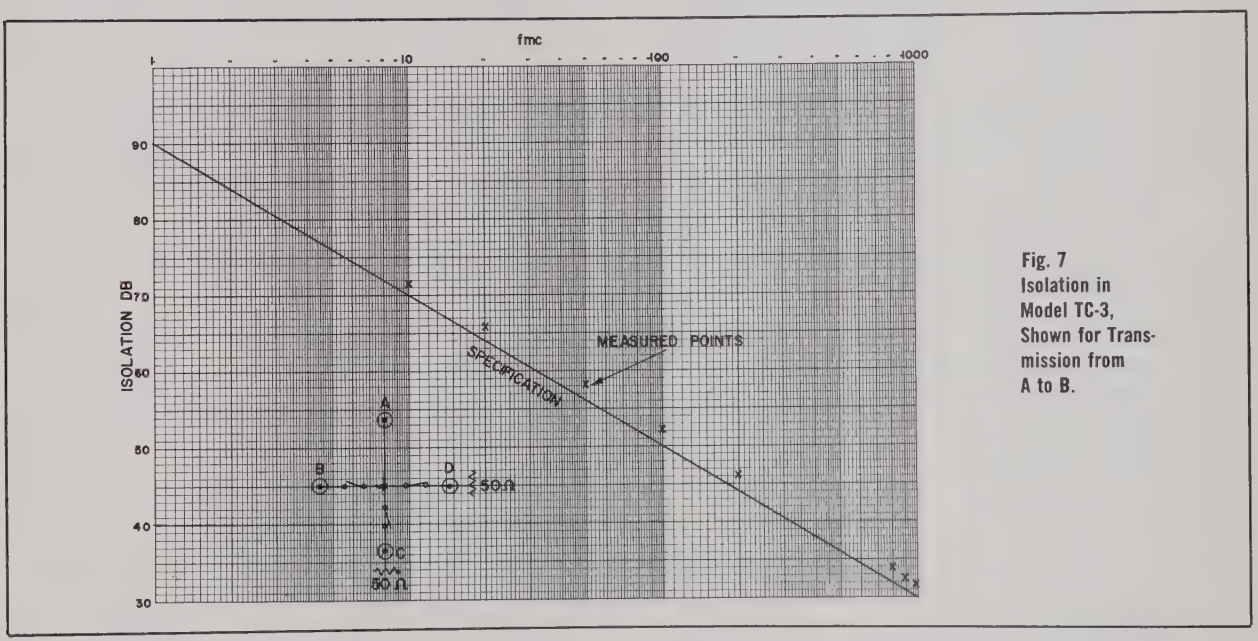


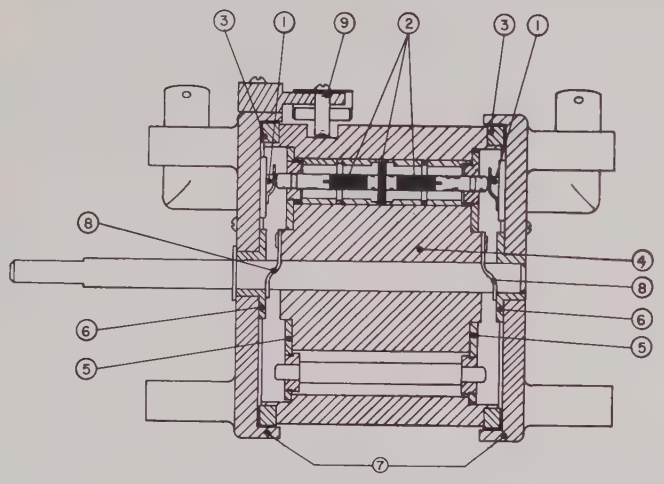
Fig. 7
Isolation in
Model TC-3,
Shown for Trans-
mission from
A to B.

MODEL ATV ATTENUATORS

The design selected for the new attenuators strikes a happy compromise between two extremes. Variable attenuators available today fall into two general categories. The best commercially available units are drum attenuators with an upper frequency limit of 2 to 4 GC. Several of the available types are pull-and-turn mechanisms which have optimum electrical performance at the expense of mechanical convenience. Prices are in the vicinity of $750 to $800 for a 10-position drum. All of the best units use disc and rod assemblies with either deposited carbon or film resistors.

At the other extreme there are many types of less expensive attenuators which cost less than $200. These generally use deposited or molded carbon resistors and various switching arrangements, either the progressively additive type (like our AV-50) or rotary switches. While these are excellent for low frequency applications and have good mechanical convenience, it is very difficult to maintain acceptable performance up to 1 GC with any arrangement where resistive elements are connected into the attenuator with wire leads.

Fig. 2 illustrates a rack-mounting bank of attenuators (Model ATV-109). A cross-section view of a turret is given in Figure 8. The highest quality deposited carbon rod and disc assemblies are used, mounted coaxially to take full advantage of their excellent match and attenuation capabilities. Spring contacts are employed between the attenuator element and the input and output connectors. While this construction does not provide as good a coaxial connection as might be obtained with a pull-and-turn arrangement, with careful design it has been made to give excellent performance to our top frequency objective of 1200 MC. The carefully-machined castings and well-designed detent ensure accurate and trouble-free operation. Complete RF shielding is assured by the use of RF gasketing material. The impedance match characteristics and attenuation accuracy of a typical 0-50 db drum are illustrated in Figures 9 and 10.



1. Coin silver contacts.
2. Disc and rod pad resistors for accuracy and long time-stability. Low VSWR assured with machined compensating sleeves.
3. Resilient rf gasketing for good ground contact and shielding.
4. Solid aluminum rotor, precision machined for accuracy and stability.
5. Important rf grounds carried by silver plated brass rings.
6. Brass bearing inserts for minimum wear.
7. Machined aluminum end castings to maintain alignment.
8. Coin silver inner contact grounding spring (necessary on some models only).
9. Positive spring-loaded ball bearing detent mechanism with faultless resolution.

Fig. 8—Cross-Section of Turret Attenuator

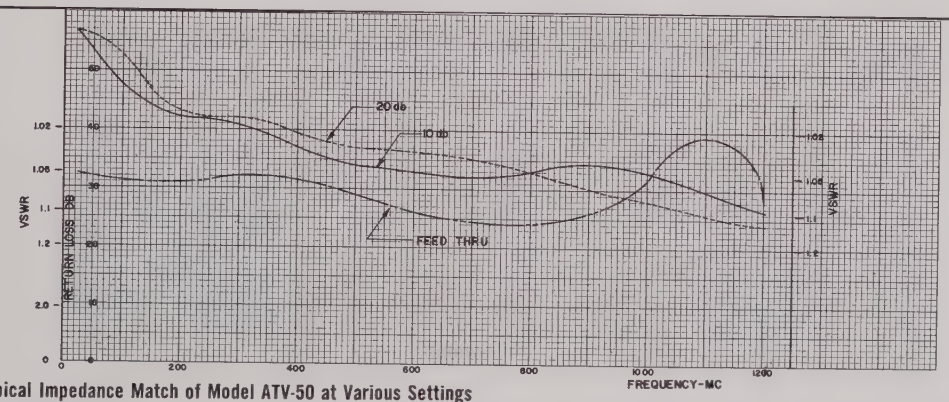


Fig. 9—Typical Impedance Match of Model ATV-50 at Various Settings

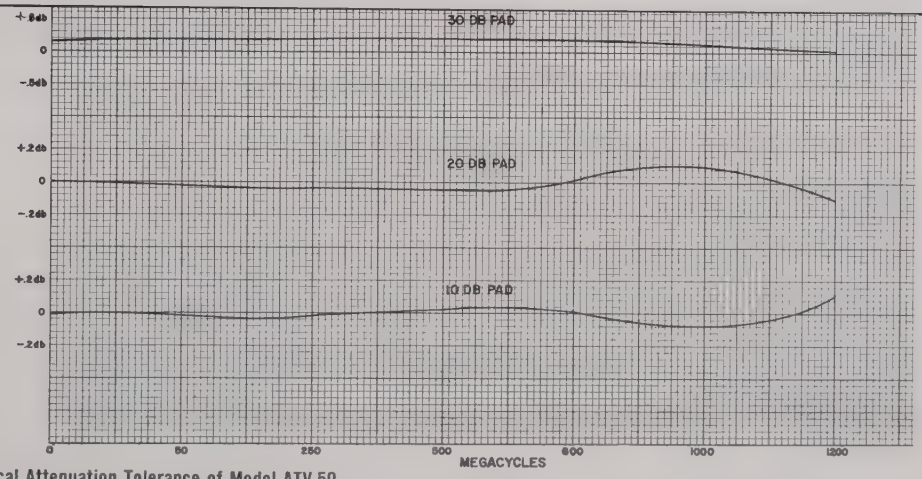


Fig. 10—Typical Attenuation Tolerance of Model ATV-50

Design of the attenuators and comparators was carried out under the direction of Henry Arbeiter. He also is responsible for electrical design of the attenuator, working with Eric Winston on mechanical design. John Austin designed the reed-relay heads on the TC-3, Frank Egenstafer is responsible for the transistor driver, and Earl Nickerson for the styling.

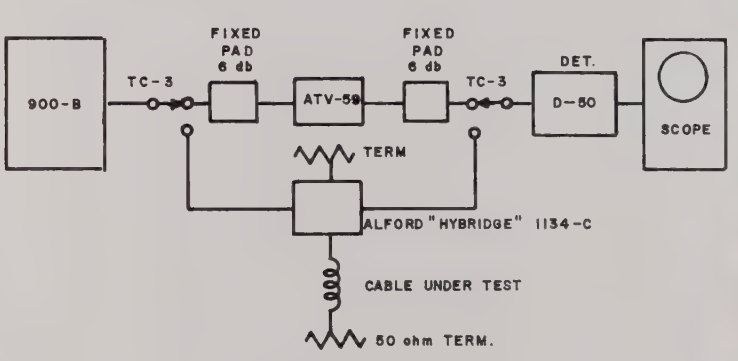
MODEL 890 WIDE-BAND SWEEPER

Model 890

Latest in Jerrold's proven group of sweep frequency generators is the new, moderately priced Model 890. This sweeper, although somewhat less sophisticated in its design than the Model 900-A, nevertheless incorporates all of that instrument's basic circuitry necessary to permit a highly economical production line test set-up.

Together with the new comparator and attenuators, the 890 will afford fast, repetitive measurements for simultaneous low and high limit comparison. Tests can be made up into the UHF range of 1100 MC, at a top center frequency setting of 1000 MC with a sweep width variable from 100 KC min. to ± 10% of center frequency.

TYPICAL APPLICATIONS IN MEASUREMENTS BY COMPARISON



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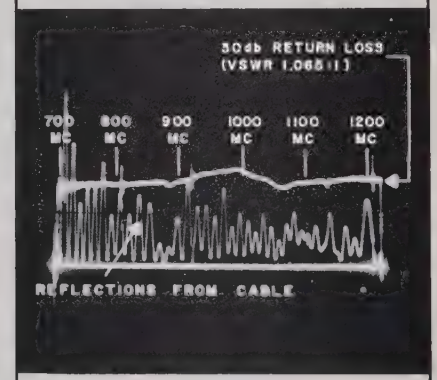
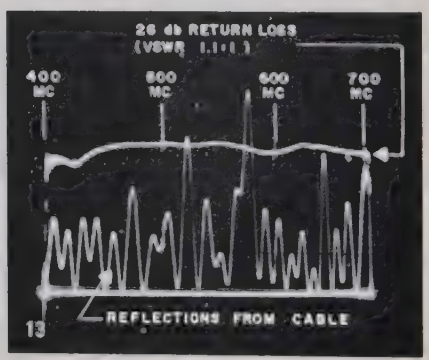


12

Application of Models TC-3 and ATV-50 in testing the impedance characteristics of coaxial cables. The test involved approximately 50 ft. of type RG-8A/U flexible coaxial cable, carefully terminated at the other end. Photo 12 illustrates the trace for measurement between 700 and 1200 MC; photo 13 illustrates the trace for measurement between 400 and 700 MC. The impedance variations on each trace are due to mechanical irregularities in the tested cable.

Note that there are decidedly less irregularities in photo 12, where the cable would meet a specification of 30 db (better than most cables).



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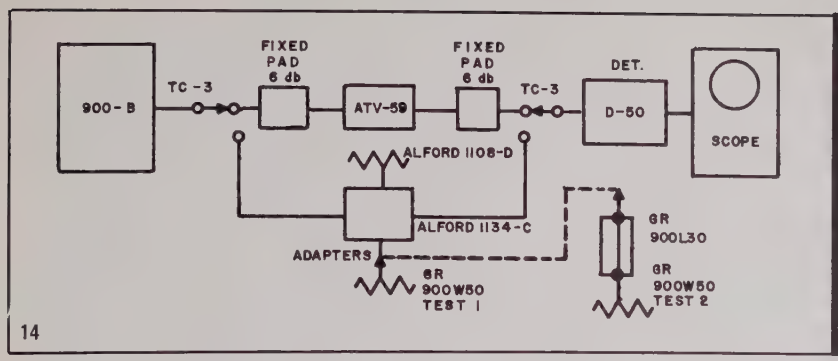

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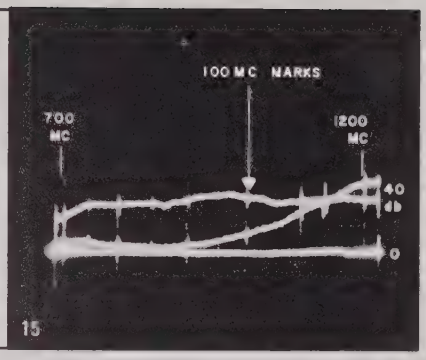


15

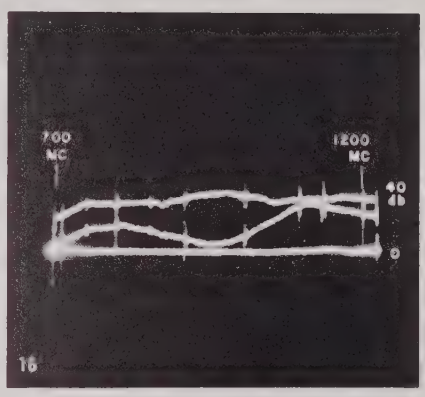
Application of Models TC-3 and ATV-50 in testing the sensitivity of Model 900-B and for checking the accuracy of the bridge test set-up.
Two tests were made:

1. connecting a General Radio type 900W50 precision 50-ohm termination through two adapters, first a General Radio type 900Q874, followed by a General Radio type 874QNP, to the bridge.

   Photo 15 shows that the bridge measured somewhat better than 40 db match (VSWR 1.02:1) up to 1100 MC.

2. connecting a 30 cm length of precise 50-ohm air dielectric line, General Radio type 900L30, between the termination and the 900Q874 adapter.

   If the characteristic impedance of the air line were exactly equal to that of the termination, the impedance would be unchanged in the second test. As seen in photo 16, there was a slight change, but the resulting impedance was still seen by the bridge as better than a 40 db match.



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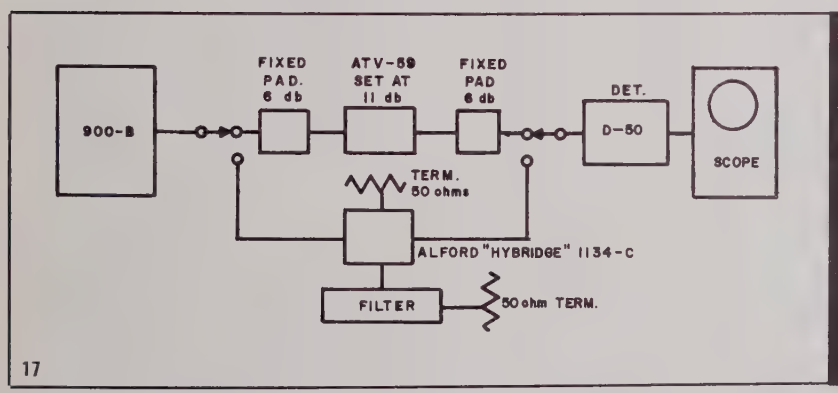

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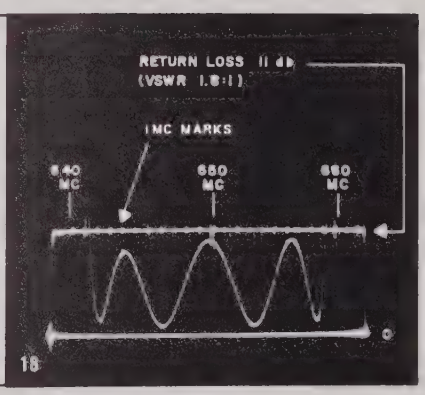
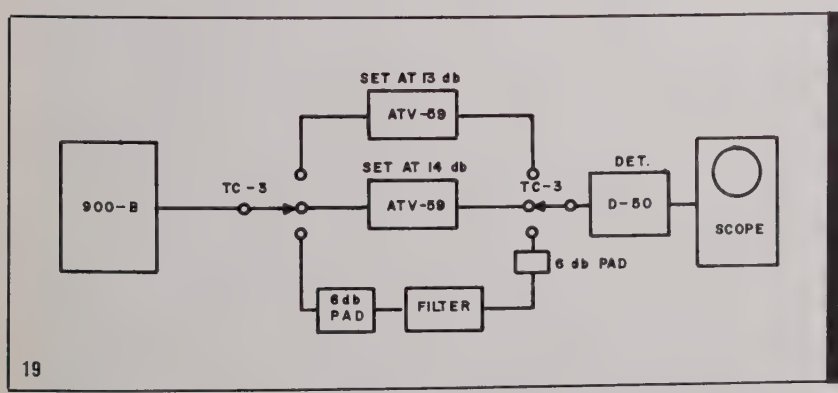


18

Application of Models TC-3 and ATV-50 to impedance match measurement on a four-pole band-pass filter.



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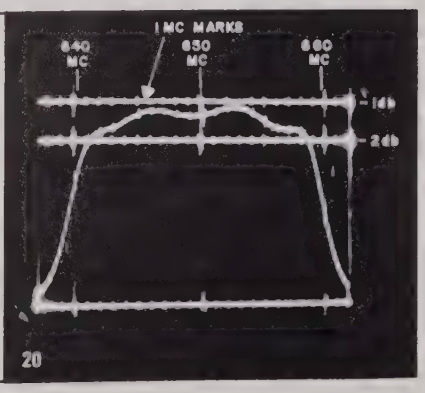
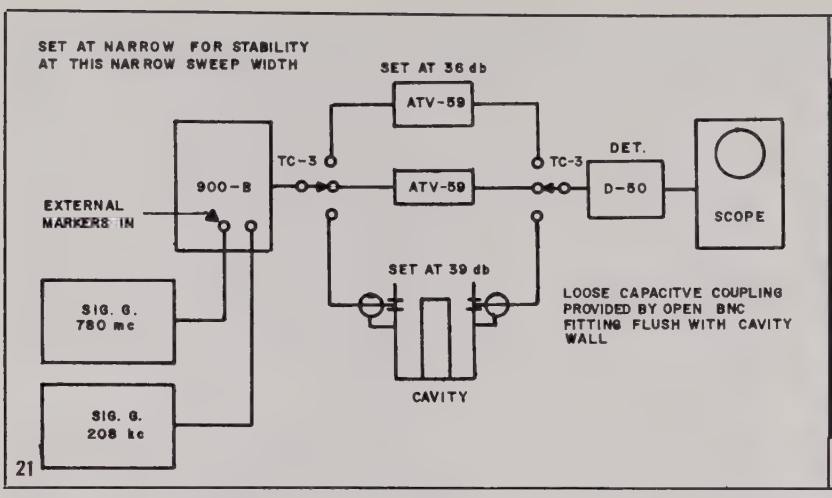
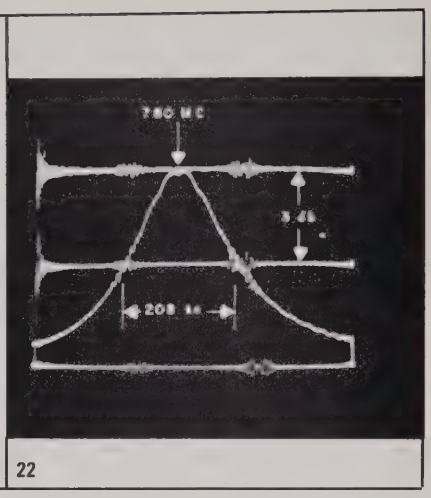


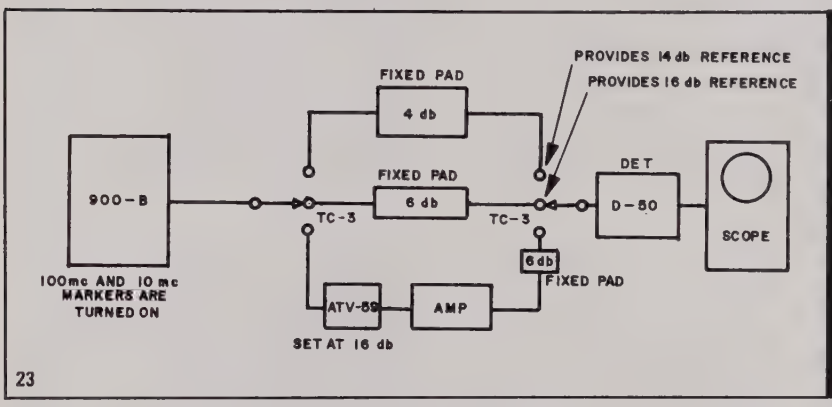
20

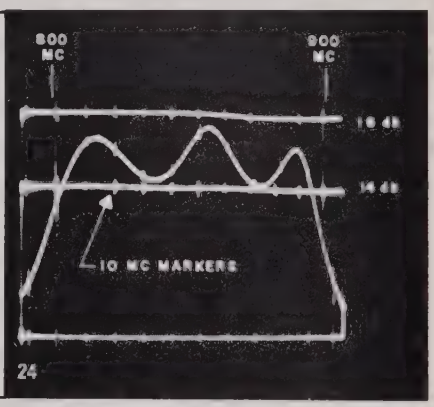
Application of Models TC-3 and ATV-50 to measurement of insertion loss of filter the match of which was shown in photo 18.



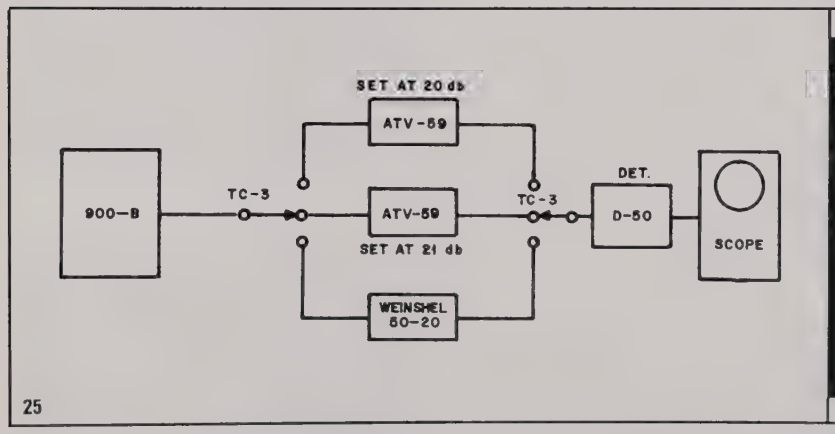


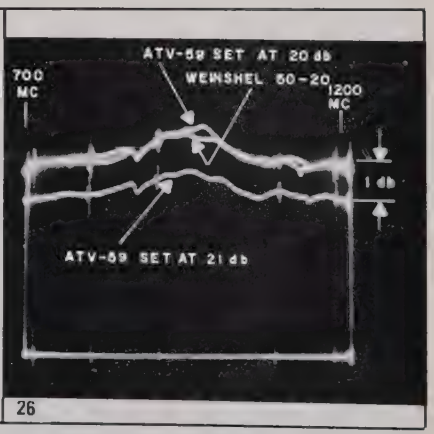
Application of Models TC-3 and ATV-50 to measurement of unloaded bandwidth and thus Q of 780 mc resonant cavity. Resulting $Q = \frac{fo}{\Delta f} = \frac{780}{0.208} = 3750$





Application of Models TC-3 and ATV-50 to measurement of gain of a transistorized UHF amplifier. Gain limits are 16 and 14 db; design bandwidth was 806 to 890 MC.





Comparison of Model ATV-50 with a Weinshel attenuator pad which had been calibrated at 20.0 db at 1000 MC. Differences between the two curves are about 0.1 db maximum, some of which is due to short cable jumpers.

NOTE — Additional copies of this paper and engineering assistance on the application of Measurements By Comparison may be obtained by contacting the Industrial Products Division, Jerrold Electronics Corporation, 15th & Lehigh, Phila., Pa. 19132. Phone: BAldwin 6-3456 — Ext. 215.

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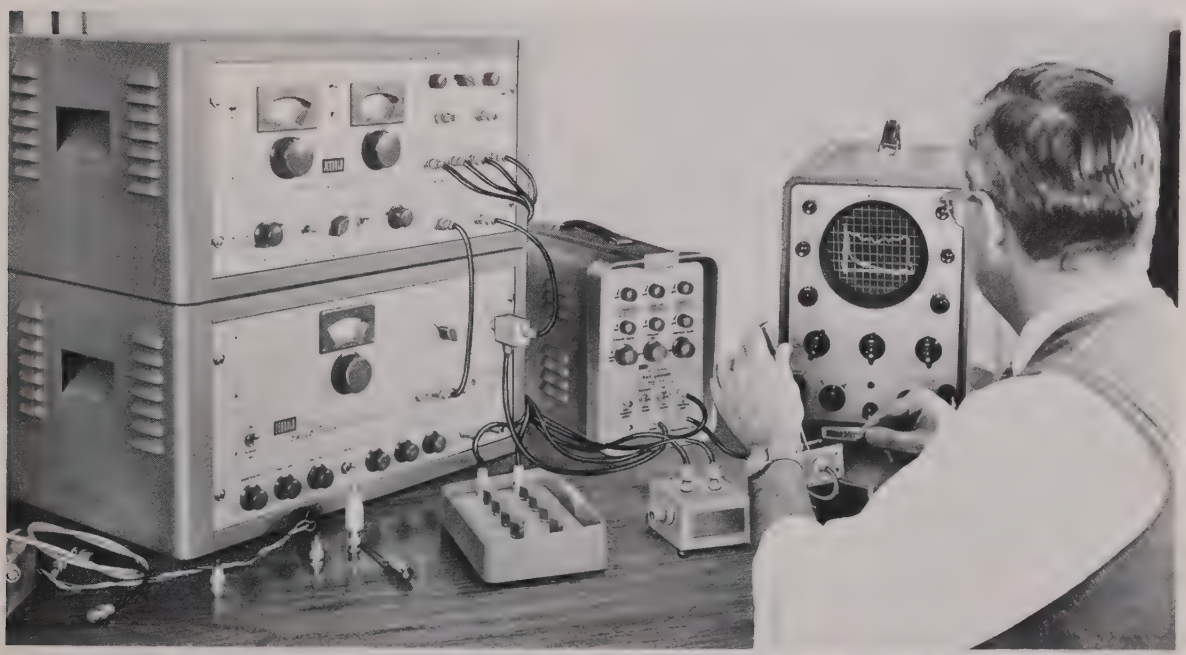
A Bridge Method of Sweep Frequency Impedance Measurement

by KEN SIMONS, Chief Engineer, Jerrold Electronics Corp.

The following is an extract of a speech given by Mr. Simons at the First Annual Eastern Engineering Seminar, May 5, 1960, Hotel Bradford, Boston, Massachusetts.

SUMMARY:

A matched bridge circuit is described providing oscilloscopic display and measurement of return loss vs. frequency. Units have been constructed allowing measurement of 50 db return loss over a 50 to 1 frequency range (4-200 MC). The technique is useful from low audio frequencies up to several hundred megacycles.



A typical test set-up utilizing Jerrold Models—900-A Sweep Frequency Generator, VC-12 Voltage Comparator, CM-6 Marker Generator, AV-75 Variable Attenuator and KSB-75 ohm Bridge; to show an optimum termination, 4 mcs to 100 mcs, with a 50 db reference.

FUNDAMENTALS:

Since high frequency measurements frequently require unavoidable lengths of transmission line, high frequency measuring techniques usually involve an application of transmission line principles. The bridge circuit to be described is no exception. Understanding its operation requires a clear picture of the concepts of reflection coefficient and return loss.

Consider an AC generator with internal impedance Ro and a voltage E as illustrated in Figure 1 (a). When the output

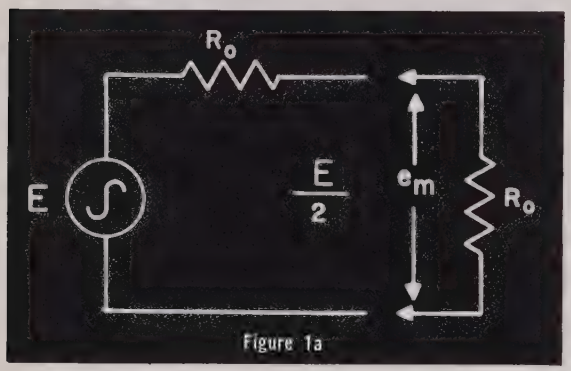


Figure 1a

of this generator is connected to a load having an impedance equal to Ro, the output voltage is $\frac{E}{2}$. In the particular case where this load is the input impedance of a section of transmission line having a characteristic impedance Ro, it is convenient to consider the input voltage as consisting of two components—a main voltage wave (e_m) which travels down the line away from the generator, and a reflected wave (e_r) which travels back from the far end towards the generator. When the transmission line section is terminated in Ro, the reflected wave is zero and the input voltage is simply e_m Figure 1 (b).

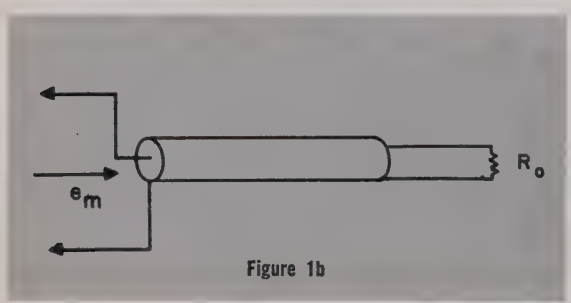


Figure 1b

This terminology can be applied even when there is no transmission line in the circuit. It may correctly be said in reference to Figure 1 (a) that the voltage across the load Ro is e_m.

In the case where the generator feeds a section of transmission line terminated in some impedance other than Ro, the input voltage can be considered to be the sum of e_m and e_r (Figure 1c). Similarly the voltage across any load

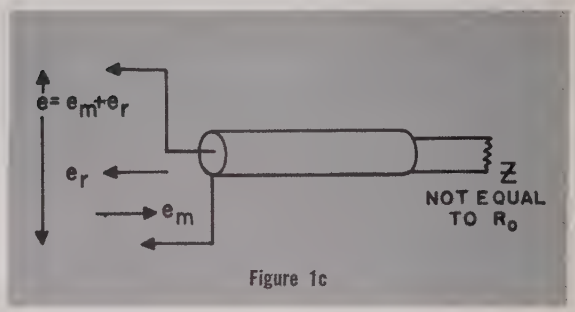


Figure 1c

connected to a generator can be considered to be the sum of a main wave and a reflected wave (Figure 1d).

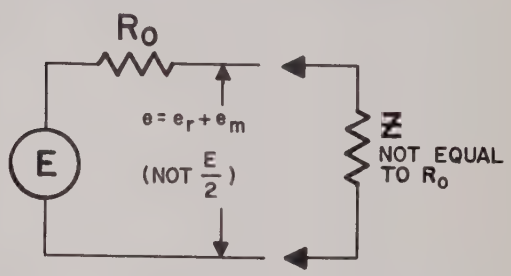
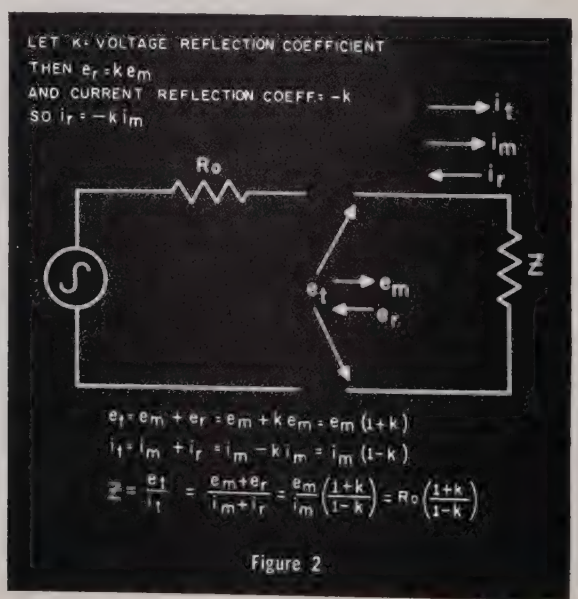


Figure 1d

A convenient way of describing the relation between the main and reflected waves is to use the reflection coefficient. Figure 2 illustrates a generator feeding a load having any impedance "Z". The voltage and current across this load


LET k= VOLTAGE REFLECTION COEFFICIENT
THEN er = k em
AND CURRENT REFLECTION COEFF: = -k
SO ir = -k im
it
im
ir
Ro
Z
et
em
er
et = em + er = em + k em = em (1+k)
it = im + ir = im - k im = im (1-k)
Z = et/it = (em+er)/(im+ir) = (em/im)((1+k)/(1-k)) = Ro((1+k)/(1-k))
Figure 2

are expressed in terms of their main and reflected components. The quantity k is defined as the ratio of the reflected voltage e_r to the main voltage e_m. The current reflection coefficient is numerically equal to the voltage reflection coefficient and has the opposite sign, so that the relationships indicated in Figure 2 hold true. A significant point is that the impedance of the load can be fully described by the internal impedance of the generator and the voltage reflection coefficient. The relation is:

$$\bar{Z} = Ro \frac{1 + k}{1 - k}$$

Note that k is a complex number involving the relation between not only the magnitudes of the main wave and reflected wave, but also their phase angles.

A further convenience is achieved by expressing the reflection coefficient logarithmically. The "Return Loss" is defined as 20 $\log_{10}\frac{1}{k}$. Thus, it is the ratio of e_r to e_m expressed in decibels. The interrelation between Return Loss, Reflection Coefficient and VSWR is indicated on the Nomograph of Figure 3.

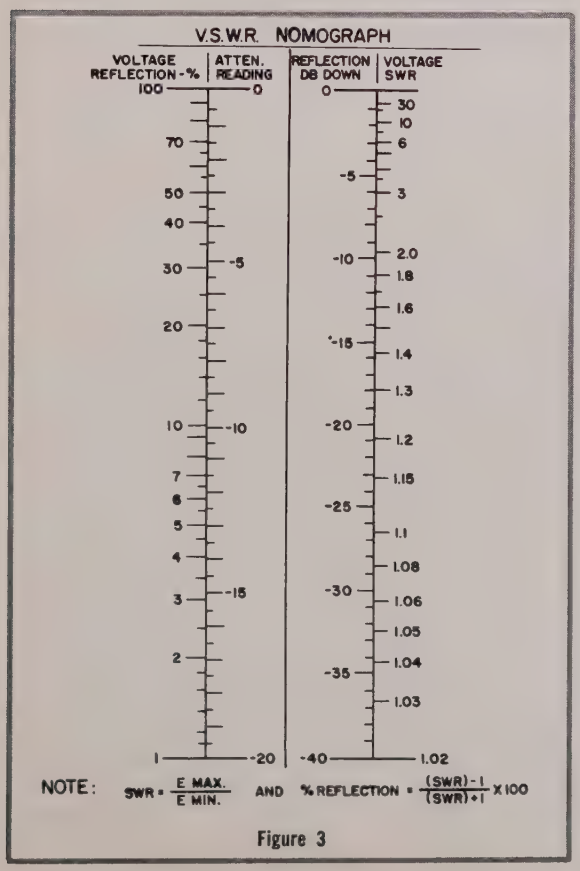

V.S.W.R. NOMOGRAPH
VOLTAGE REFLECTION - %
ATTEN. READING
REFLECTION DB DOWN
VOLTAGE SWR
NOTE: SWR = E MAX. / E MIN. AND % REFLECTION = (SWR)-1 / (SWR)+1 X 100

Figure 3

THE BRIDGE PRINCIPLE:

A convenient way of measuring an unknown impedance would be to separate the reflected wave from the main wave and to measure its relative magnitude and phase angle. This is commonly done in high-frequency and microwave testing by the use of a directional coupler. Another approach is the use of a bridge.

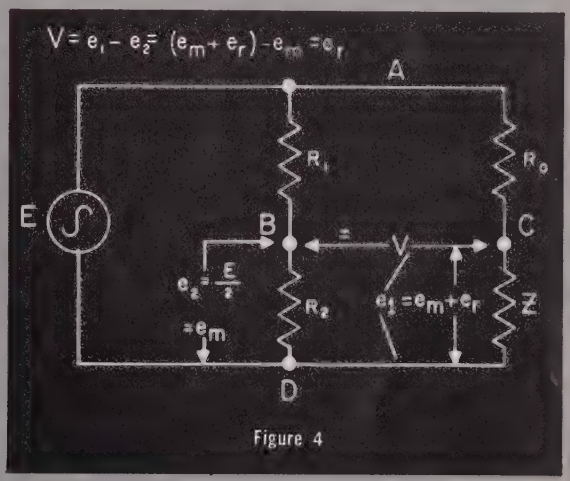


Figure 4

Figure 4 illustrates how a bridge can provide a voltage equal to the reflected wave. A generator having zero internal impedance feeds a load $\bar{Z}$ through a resistor Ro. The voltage e_r across $\bar{Z}$ is equal by definition to e_m plus e_r. If a second divider consisting of two equal resistances R_1 and R_2 is connected across the voltage source, the voltage e_2 across the lower resistor will be equal to $\frac{E}{2}$ which is the same as e_m. If the voltage between the center points of the two dividers is measured, it is found to be the difference between e_m plus e_r and e_m, which is e_r. Thus, the output voltage "V" of this network is identical to the reflected voltage component from the impedance $\bar{Z}$.

THE TERMINATED BRIDGE:

Unfortunately, this simple circuit involves the use of a voltage source having zero internal impedance and a voltage measuring device having infinite impedance which measures the difference of voltage between two points, neither of them grounded. As a practical matter, these conditions are difficult to approach.

Fortunately, an alternative configuration is available. The terminated bridge illustrated in Figure 5 has several characteristics which make it especially suitable for this application. When all six resistances are equal, the impedance seen looking into the network at the terminals left after disconnecting any one of the resistances is always equal to Ro. Thus, for example, in Figure 5 the impedance seen between A and D with #1 resistor removed is equal to Ro. When the resistors are equal to the characteristic impedance of a particular coaxial cable, the bridge has matched input and output impedances.

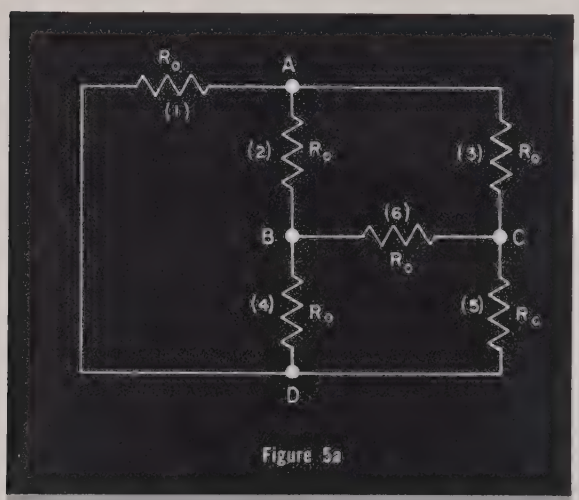


Figure 5a

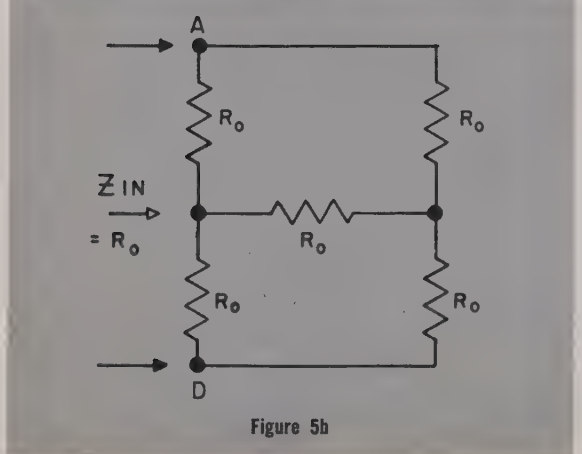
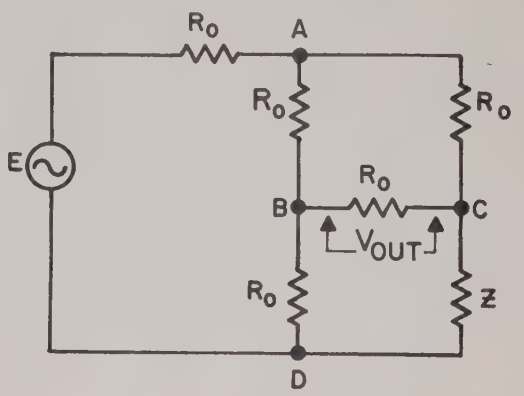


Figure 5b

The terminated bridge has the further advantage that it provides an output voltage precisely equal in magnitude and phase to a constant times the reflection coefficient of the unknown. This is illustrated in Figure 6 which states



$$\text{TRANSMISSION LOSS IS } 20 \log_{10} \left(\frac{E}{2\, V_{OUT}} \right)$$

$$= 20 \log_{10} 4 \times \frac{Z+R_o}{Z-R_o} = \text{RETURN LOSS OF } Z+12\,db$$

Figure 6

that the transmission loss from the input terminals of the bridge, to Vout is equal to the return loss of Z (referred to Ro) plus 12 db. This relation is fully derived in Appendix I. It may be understood better by referring to Figures 7 and 8. Figure 7 shows that the input voltage to a matched load connected between C and D (e_m) is equal to the bridge input Vin reduced by 6 db.

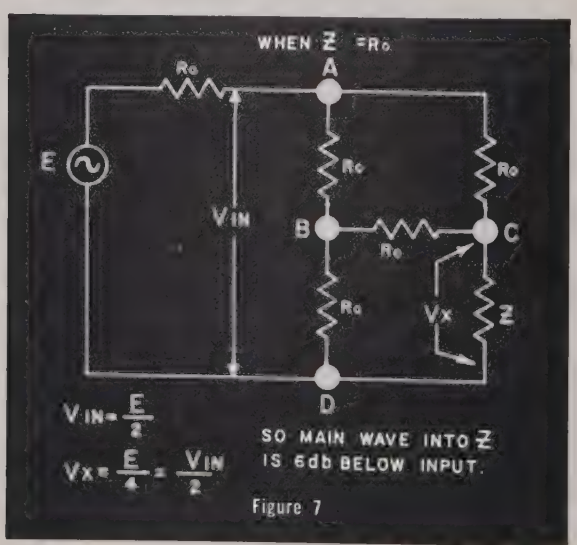


Figure 7

In Figure 8 the bridge is redrawn to show the voltage division experienced by the return wave from Z. It comes back into terminals C and D and is attenuated 6 db before coming out of terminals B and C.

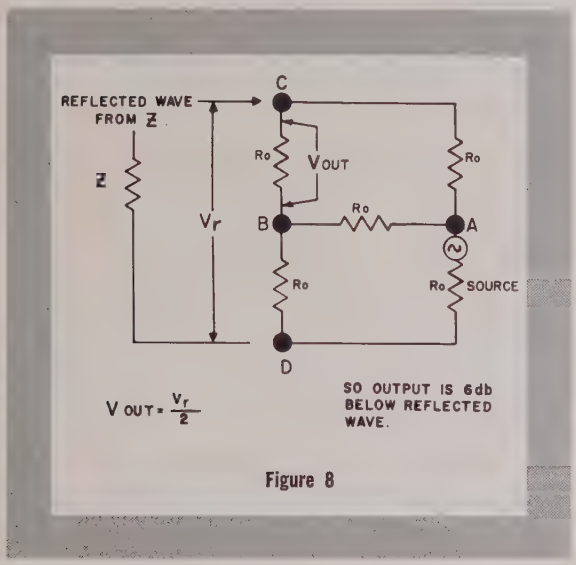


Figure 8

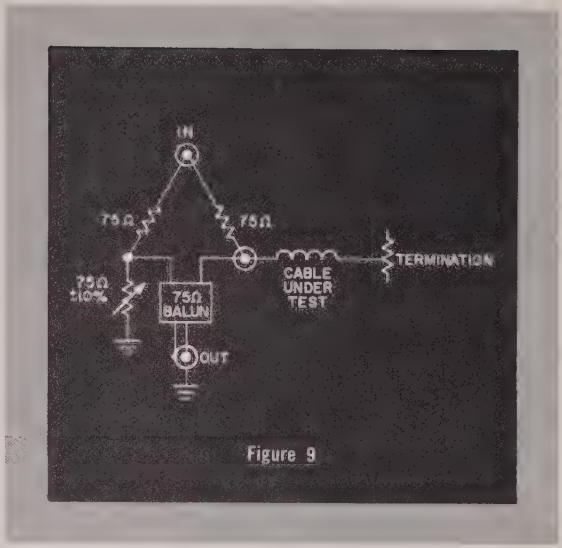


Figure 9

As compared with the simple bridge circuit illustrated in Figure 4, the matched bridge has the advantage that the input and output impedances match connecting coaxial cables so that wide band frequency performance can be obtained. The problem of providing a differential voltage measurement between two ungrounded terminals is still present. To build a matched bridge practically, it is necessary to provide a transformer having balanced input terminals as illustrated in Figure 9. It has been found possible to build such a transformer with a very wide range of frequency response. The resulting bridge is conveniently connected to provide a calibrated sweep display as illustrated in Figure 10. A high-speed coaxial switch (Jerrold Model FD-30) is connected so that in the "up" position it connects the output of the sweep through a 12 db pad and a standard variable attenuator to the input of a wide band amplifier. The amplifier is followed by a detector and scope and displays a curve representing loss vs. frequency. In the "down" position the switches insert the bridge in place of the attenuators. Since the loss of the bridge is equal to the return loss of the unknown plus 12 db, the scope will show a plot of return loss vs. frequency with a reference line corresponding to the setting of the standard variable attenuator.

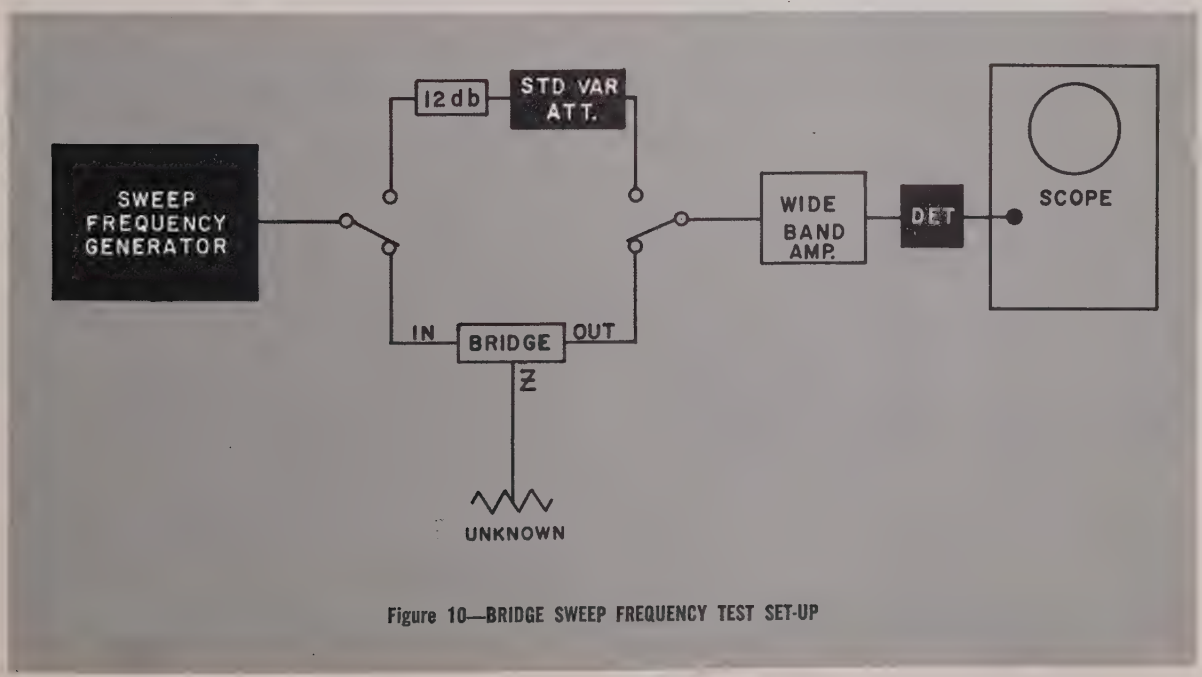


Figure 10—BRIDGE SWEEP FREQUENCY TEST SET-UP

EXAMPLES OF USE

The performance of a particular bridge is illustrated in Figures 11 to 16 inclusive. This bridge was designed for a characteristic impedance of 75 ohms and the test circuit covered a frequency range from 4 to 100 MC. Figure 11 illustrates the relation between the reference line and the bridge response with the unknown terminal of the bridge open-circuited. The bridge indicates 0 db return loss within about ½ db from 4 to 100 MC.

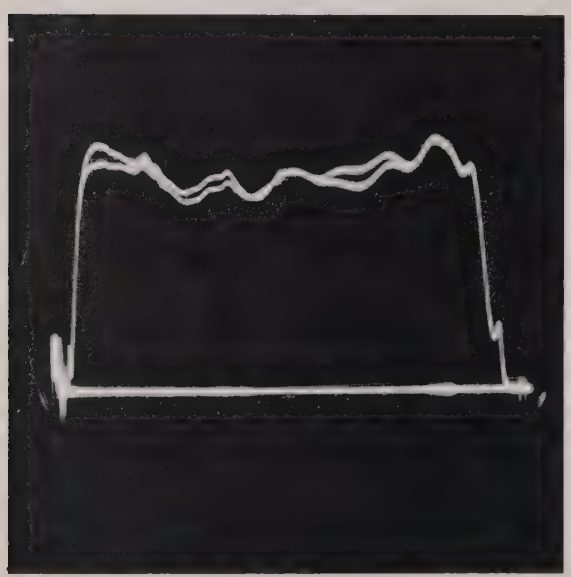


Figure 11—BRIDGE RESPONSE
4-100 mc, Open Circuit

Figure 12 shows the same situation with the unknown terminal short-circuited, again indicating 0 db return loss with approximately ½ db error.

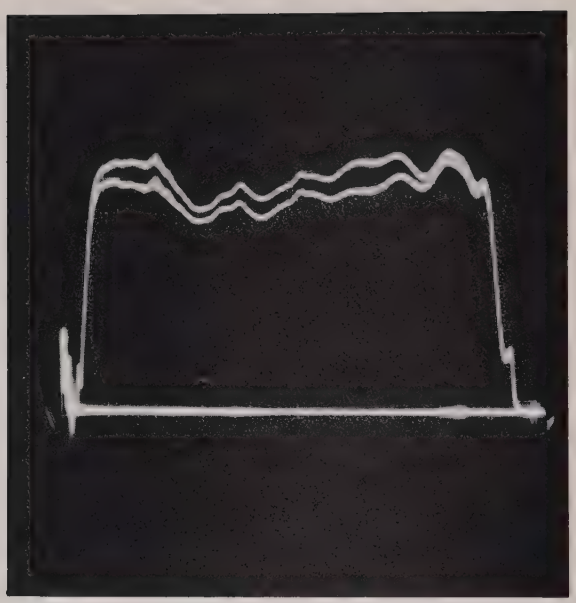


Figure 12—BRIDGE RESPONSE
4-100 mc, Short Circuit

To obtain Figure 13, the X terminal of the bridge was terminated as accurately as possible. In this figure the reference line represents a return loss of 50 db and it is seen that the loss through the bridge indicates a return loss substantially better than 50 db across this entire frequency range. A 50 db return loss corresponds to a VSWR of 1.06 so that it is apparent that this technique is capable of precision comparable with the best that can be obtained with other high frequency measuring techniques.

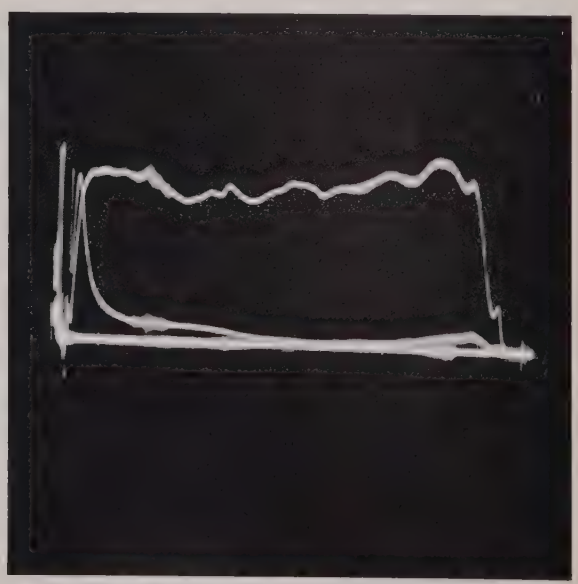


Figure 13—BRIDGE RESPONSE
4-100 mc, Optimum Termination, 50 db Reference

Although this method is extremely **precise,** i.e., it can compare an unknown with a standard and show deviations of considerably less than 1%, its **accuracy** is entirely dependent on the accuracy of the standard impedance against which the bridge is tested. Where suitable standards are available, its accuracy can be nearly as good as its precision.

Figure 14 illustrates the agreement between the reference line and the bridge loss when the bridge was first adjusted for balance with a 75 ohm resistor. A resistor was then substituted whose DC resistance was accurately adjusted to 70 ohms. A 70 ohm resistor in a 75 ohm system gives a VSWR of 1.07 or a return loss of 29.2 db. The reference line on this trace was 30 db.

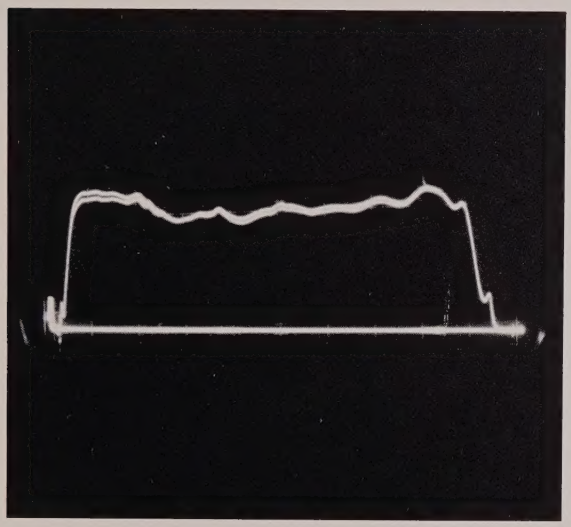


Figure 14—BRIDGE RESPONSE
4-100 mc, 70 ohm Termination, 30 db Reference

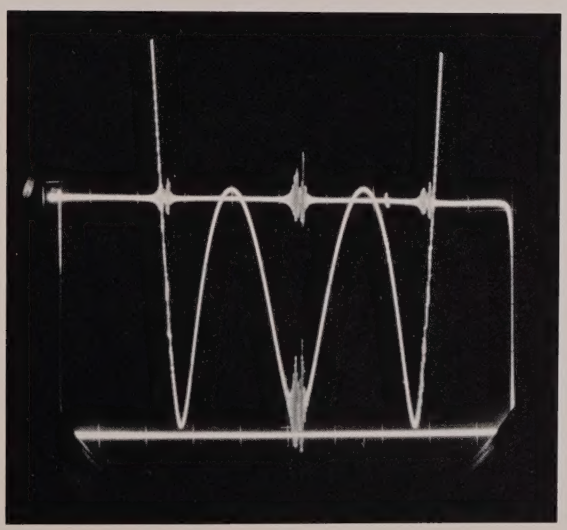


Figure 15 —BRIDGE RESPONSE
Markers 100 mc ±1.5 mc, 10 db Reference

The delay line method of sweep-frequency impedance measurement (as described in Technical Newsletter #2) provides a convenient method of measuring high frequency impedances with a minimum of equipment. Practical characteristics of delay lines limit the usefulness of this method to relatively wide frequency bands. The bridge technique has no such limitation. It is equally useful for extremely narrow-band measurements or extremely wide-band measurements.

Figure 15 shows the return loss measurement of a triple-tuned filter having a bandwidth of 1.5 MC and a maximum return loss in the pass band of approximately 10 db. Notice the simplicity of this presentation and the ease with which an operator could adjust such a filter to meet given frequency and return loss specifications.

Figure 16 illustrates an extremely wide band measurement. This shows the return loss of a piece of high-grade coaxial cable over the frequency range 4 to 100 MC with a 40 db reference. The bridge provides a way of testing this complicated function with a high degree of speed and accuracy.

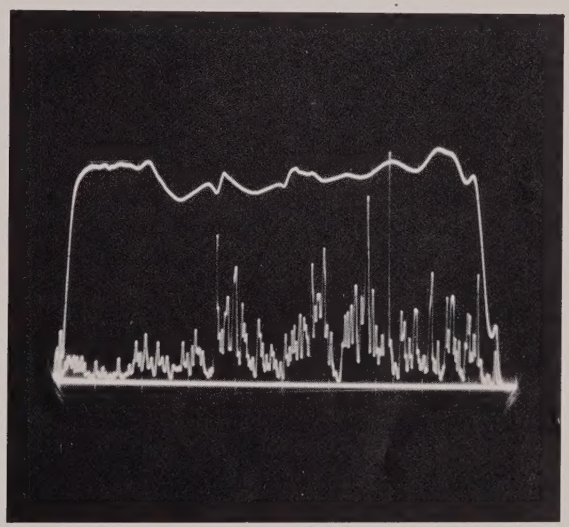
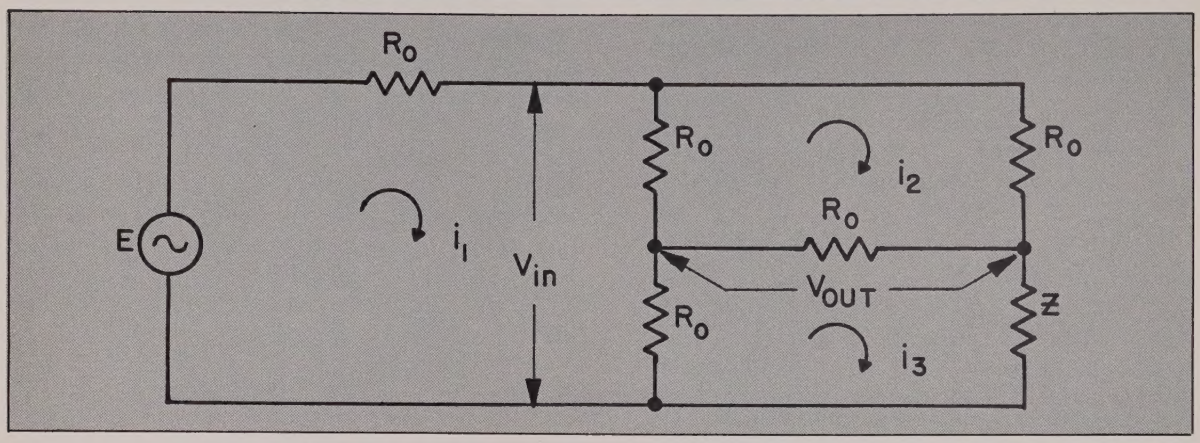


Figure 16—BRIDGE RESPONSE
4-100 mc, Input of 1000' Piece High Grade Coax., 40 db Reference

The sweep frequency technique has for many years provided a convenient way of observing the frequency variation of gain or loss. More recently it has become possible to measure these quantities simultaneously with the sweep presentation. (See Technical Newsletter #1.) The wide-band return-loss bridge now provides the same degree of convenience in viewing and measuring the frequency variation of return loss and opens a new area of speed and convenience in Laboratory and Production testing of high frequency networks.

APPENDIX



① ..... $E = 3R_0 i_1 - R_0 i_2 - R_0 i_3$

② ..... $0 = -R_0 i_1 + 3R_0 i_2 - R_0 i_3$

③ ..... $0 = -R_0 i_1 - R_0 i_2 + (Z + 2R_0) i_3$

④ ② − ③ ..... $0 = 4R_0 i_2 - (Z + 3R_0) i_3$

⑤ ① + (3 × ②) ..... $E = 8R_0 i_2 - 4R_0 i_3$

⑥ Solving ④ for i_2 ..... $i_2 = \dfrac{Z + 3R_0}{4R_0} i_3$

⑦ Substituting ⑥ in ⑤ ..... $E = 8R_0\left(\dfrac{Z + R_0}{4R_0}\right) i_3 - 4R_0 i_3 = 2(Z + R_0) i_3$

$$\text{hence } i_3 = \frac{E}{2(Z + R_0)}$$

⑧ Substituting ⑦ in ⑥ ..... $i_2 = \left(\dfrac{Z + 3R_0}{4R_0}\right)\left(\dfrac{E}{2(Z + R_0)}\right) = \left(\dfrac{E}{8R_0}\right)\left(\dfrac{Z + 3R_0}{Z + R_0}\right)$

⑨ ..... $V_{OUT} = R_0 (i_2 - i_3) = R_0\left[\left(\dfrac{E}{8R_0}\right)\left(\dfrac{Z + 3R_0}{Z + R_0}\right) - \dfrac{E}{2(Z + R_0)}\right];$

$$\text{hence } V_{OUT} = \frac{E}{8}\left(\frac{Z + 3R_0 - 4R_0}{Z + R_0}\right)$$

$$\text{and } \boxed{V_{OUT} = \frac{E}{8}\left(\frac{Z - R_0}{Z + R_0}\right)}$$

$$\text{Transmission Loss} = 20 \log_{10}\left(\frac{E}{2 V_{OUT}}\right) = 20 \log_{10}\left[\frac{E8\,(Z + R_0)}{2E\,(Z - R_0)}\right] =$$

$$= 20 \log_{10} 4\left(\frac{Z + R_0}{Z - R_0}\right) = \text{Return Loss of } Z + 12 \text{ db}$$

NOTE— Additional copies of this paper and engineering assistance on the application of Measurements By Comparison may be obtanied by contacting the Industrial Products Division, Jerrold Electronics Corporation, 15th & Lehigh, Phila., Pa. 19132. Phone: BAldwin 6-3456 — Ext. 215.

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